

Aarhus School of Architecture // Design School Kolding // Royal Danish Academy

## Life Cycle Thinking and Integrated Product Deliveries in renovation projects: Extending the concept of Integrated Product Deliveries with Product Service Systems

Schipull Kauschen, Jan

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29 & 30 October 2012

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Project Coordinator, Wuppertal Institute, Germany

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# Papers

# Biomimicry Sketch Analysis: A Generative Tool for Sustainability in Product Design Education

Yekta Bakırlıođlu

Research Assistant and Graduate Student

METU Department of Industrial Design

Faculty of Architecture

Üniversiteler Mah. Dumlupınar Blv. No:1

06800 Çankaya Ankara

Turkey

Çađla Dođan

Assististant Professor Dr.

METU Department of Industrial Design

Faculty of Architecture

Üniversiteler Mah. Dumlupınar Blv. No:1

06800 Çankaya Ankara

Turkey

## Abstract

In this paper, a generative tool, namely *Biomimicry Sketch Analysis* (BSA), is introduced within the context of an educational project. To explore the implications of it for sustainability, conclusions from and insights into a graduate research are presented. The primary emphasis of this research is on the integration of *biomimicry* into the idea generation phase of the design process. The educational project was carried out in the Department of Industrial Design at METU in Fall 2011 in collaboration with one of the major bathroom products and accessories producers in Turkey. Within the scope of this project, a *family of products* was developed through rethinking and reintegrating ceramic bathroom accessories with bathroom tiles. In this project, the third year design students explored the implications of *biomimicry* strategies for the sustainable design considerations (i.e. product maintenance, repair, upgrading and personalization) to bring together bathroom accessories and tiles.

## Introduction

The ways humans produce and consume have been affecting the world dramatically ever since the industrial revolution. Our intervention in the environment has been through considering and utilizing nature as a rich source of raw materials (both renewable and non-renewable), and this process has turned into a rapid extraction of raw materials from nature, causing urging problems from the environmental pollution to the depletion of natural resources. Consequently, the excessive consumption patterns and over-production of goods led towards drastic changes on nature.

As one of the approaches for sustainability, biomimicry constitutes the potential in achieving sustainability. Taking nature as a mentor and a rich source of inspiration through observing its models, systems and processes, could help in the pursuit of sustainability, in terms of not only environmental stewardship, but also social well-being and economic feasibility. Yet, the implications of the biomimicry approach for sustainable product design education have not been fully explored.

Benyus (1997) gives the underlying definition of biomimicry in the title of her book: 'innovation inspired by nature', and she points out the potential of biomimicry in finding solutions to human problems. It is logical to observe nature and learn from its models and systems for sustainability, since nature is a system with complete mastery of sustainable development (Ternaux 2011). One of the challenges in

incorporating the biomimicry approach is the interdisciplinary nature of it, which counter-balances its considerable potential (Yen & Weissburg 2007). The current applications of biomimicry focus on reductionism in raw material, energy, waste, etc. which narrows the use of it to solve particular problems in conceptual and design detailing phases (Reap 2010). He suggests, by doing so, the applicability of biomimicry in the realm of environmental sustainability is limited as well, thus he offers a more holistic approach in re-imagining whole systems via the biomimicry approach. In this study, the notions of biomimicry and sustainability were concurrently incorporated into the early stages of the idea-generation phase to explore and achieve sustainable design considerations.

### Sustainable Design Considerations

The area of product design for sustainability evolves through multi-faceted and complex issues considering the environmental, social and economic tenets of sustainability. Current unsustainable consumption patterns have implications for material culture considering rapid product obsolescence both aesthetically and technically (Papanek 1985), which has to be challenged and reconsidered within the context of sustainability (Chapman 2005, Walker 2006).

Sustainable consumption and production appear to be an evolving area for many designers and researchers, which includes interrelated aspects of sustainability such as elongating life spans of products, designing products adaptable to local and regional resources and conditions, and enabling product maintenance, repair, upgrading, etc. (Walker 2011, Walker, Dogan & Marchand 2009, Marchand & Walker 2007, Dogan 2007, Ramakers 2002, 1998, Verbeek & Kockelkoren 1998). The biomimicry approach constitutes similar considerations for sustainability (i.e. be locally attuned and responsive, evolve to survive, and adapt to changing conditions) within its framework (i.e. Life's principles), yet this is used for evaluating the resulting designs.

### Design Research on Biomimicry Sketch Analysis (BSA) Exercise

This graduate research focuses on an educational project in product design with an emphasis on sustainability considerations - i.e. product maintenance, repair, upgrading, and personalization. The design project was carried out with the third year design students in the Department of Industrial Design at METU in Fall 2011, and was conducted in collaboration with Kale Group, one of the major ceramic tiles and accessories producers in Turkey. The aim of the project was to develop sustainable design solutions integrating bathroom accessories (e.g. soap dish holders, toothbrush holders, towel bars, etc.) with bathroom tiles. The Biomimicry Sketch Analysis (BSA) exercise was incorporated into the idea generation phase of this project as a three-day exercise to further explore the sustainability considerations.

BSA is an idea-generation tool, and is positioned right after the research phase of the design process - e.g. literature search, user observations. In an educational project, the sustainable design considerations - i.e. product maintenance, repair, upgrading, personalization, etc. - are defined more in-depth based on the project at hand. For the BSA exercise to be effective in regard to sustainability, these considerations are interpreted within the biomimicry approach through *strategies from nature* derived from Biomimicry Taxonomy (source: asknature.org). Defining the strategies is an important part of the BSA exercise as they constitute the aim, content and direction of the exercise, which are sustainable design considerations in this study. The BSA exercise creates a transition between research and idea-generation phases of the design process, as it brings together the observation and analysis of the inspiration source, and its transfer into an idea for the design project. Consequently, BSA shows considerable potential in the creation of sustainable ideas from the beginning of the design process.

The main focus of the exercise was challenge to biology. BSA was developed to let the design students observe, explore and document natural systems within their nearby environment and develop diverse solutions inspired from nature. As presented in Table 1 in relation to the design process, it consists of three main stages:

- **Observation:** Involving the observation skills of designer without the necessity of inherent biology knowledge
- **Analysis:** Utilizing sketching and visualizing skills of designer to understand the way the natural systems work



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- **Transfer:** Stimulating the creativity of designer to transfer the findings into solutions

The exercise was carried out individually in order not to limit the students' own perspectives on nature and its models and systems. For this exercise, the use of online databases or sources to find inspirations was limited, and the students were encouraged to go out and step in the nature to make hands-on observations of natural systems, and to let them inspire from nature through using their own skills as designers. The use of any online resources was allowed after their observation stage of the BSA to further analyze the observed sources of inspirations.

Steps of Biomimicry Design Spirals	Steps of Design Process
Identifying	Research
Interpreting – Observation	<b>Idea Generation (divergence)</b>
Discovering – Analysis	
Abstracting – Transfer	
Emulating	Design Detailing (convergence)
Evaluating	Evaluation and Appropriation
<b>Final Design</b>	

Table 1 - Positioning of the BSA exercise at the idea-generation phase.

The students were asked to present three different natural systems and organisms, based on the strategies inspired by nature as presented below. They were free to choose an alternative strategy or make an additional one for those two. The strategies were defined as stated in the Biomimicry Taxonomy developed by the Biomimicry Institute and the examples of those strategies were given from Asknature.org, through a seminar presented right before the assignment. The strategies are as follows:

- **attach and detach** - permanent or temporary
- **adapt** - optimizing space or materials, modifying physical state such as changing form, color, or position
- **self-defined** (optional) - i.e. (self-) clean, resist forces, etc.

As for presenting their results of the BSA, the students were expected to present photographs of three sources of inspiration they chose, and to prepare three different A3 detailed hand-sketch analysis describing the source of inspiration, its unique feature(s) and component(s), and the implications of the feature(s). An example of BSA is given in Figure 1.

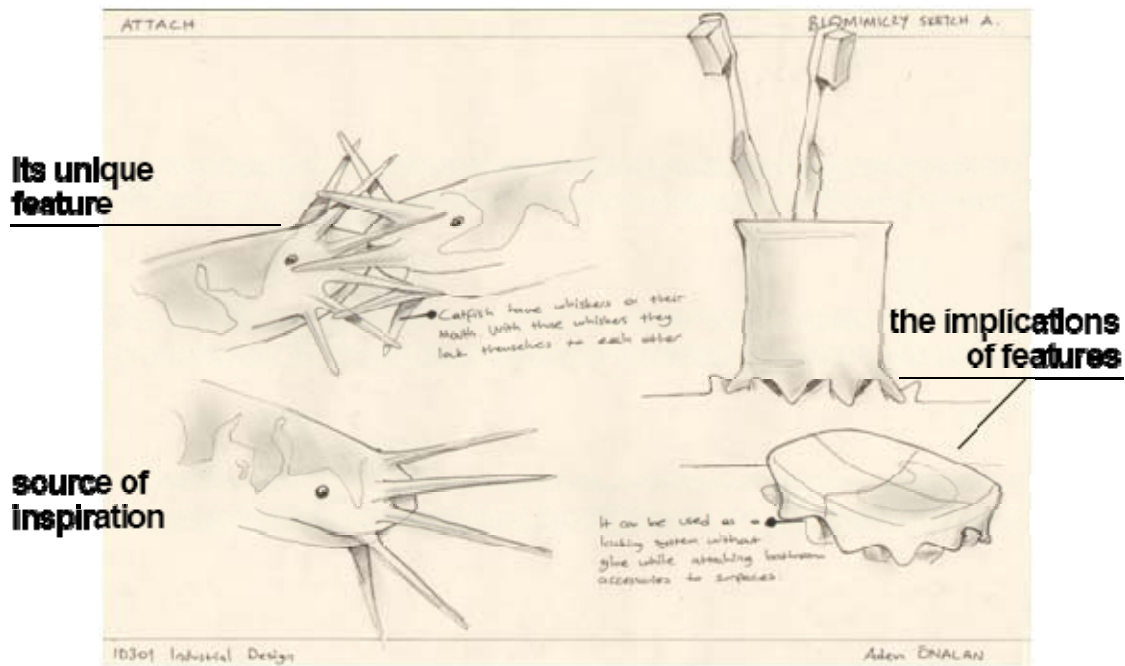


Figure 1 - An example of BSA exercise presented by Adem Önalán

After the submission, the results of the BSA assignment were presented on the white boards of the studio. The students observed what everyone else presented for the inspiration sources, and how they incorporated the inspiration source into their initial designs and reflected on the results. The aim for this was to let the students explore and examine others' perspectives in incorporating nature's models and systems into the project.

### Interview results with the industrial design students

Upon analyzing the results of the interviews and the project outcomes, the students were categorized into four groups with respect to the incorporation of the biomimicry approach:

- Group 1: These students found the biomimicry approach helpful and developed a design project inspired and informed by nature (11 out of 33 students).
- Group 2: These students found the biomimicry approach helpful, yet they were not able to develop design projects inspired and informed by nature (10 out of 33 students).
- Group 3: These students found the biomimicry approach not helpful enough, yet they developed design projects inspired and informed by nature (6 out of 33 students).
- Group 4: These students found the biomimicry approach not helpful enough, and their design projects were not inspired and informed by nature (6 out of 33 students).

Regarding these results, two-third of the students (Groups 1 & 2) found the biomimicry approach helpful for the idea-generation phase. More than half of the students (Groups 1 & 3) developed a final design originated from a natural inspiration source. Furthermore, 8 of Groups 1 & 3 students used the biomimicry approach in all phases of the design process.

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	Group 1	Group 2	Group 3	Group 4
Creating a starting point				
Number of ideas developed				
Awareness towards the project considerations				
Awareness of nature as an inspiration source				
Necessity of a fresh start as a strategic decision				
Disbelief in the usefulness of the exercise				
Misperception of the exercise				
Lack of design critiques				

Table 2 – The students’ insights into the implications of biomimicry considering four student groups

Groups 1, 2 & 3 students mentioned that the biomimicry approach integrated into the idea-generation phase in the form of BSA exercise was influential with regards to the number of ideas developed in design studio and the awareness of nature as an inspiration source in creating design solutions. Groups 1 & 2 students stated that the BSA exercise created a starting point at the idea-generation phase, and created awareness towards project considerations as well.

Groups 3 & 4 students emphasized that the BSA exercise was incorporated into the idea-generation phase in order for them to get familiar with the biomimicry approach, thus they did not expect any useful outcomes from it. Yet, Group 3 students developed final designs originated from natural inspiration sources, whereas Group 4 students left the biomimicry approach right after the BSA exercise.

In general, the students stated that the individual conduct of the exercise led towards easier application of the exercise and increased the number of diverse ideas developed. This allowed different perspectives to emerge and various inspiration sources to accumulate. On the other hand, the students stated that group work during the observation and analysis stages of the exercise could lead towards outcomes of better quality in the transfer stage.

Most of the students stated that the biomimicry seminar presented prior to the BSA exercise was helpful in gaining basic information on biomimicry and BSA, as well as a critical perspective on nature as an inspiration source. From their point of view, the strategies from nature defined prior to the exercise (i.e. attach-detach, adapt, etc.) and examples on them were helpful in observing nature and finding inspiration sources that would be useful for the project. Some of the students also revealed that there should have been more examples on strategies from nature to broaden their perspectives further.

Nearly half of the students (15 out of 33) perceived the aim of the BSA as increasing awareness on biomimicry, while 10 out of 33 students considered it as conveying a more critical perspective on nature. Only 7 out of 33 students stated that the aim of it was to learn how to use biomimicry for sustainability, even though the outcomes of the BSA exercise was in line with the sustainable design considerations for the project. This suggested that the relation between the sustainability considerations and the BSA exercise should have been conveyed more clearly to the students.

### Exemplary Student Cases

In order to present how the BSA exercise affected the following project phases, it seemed appropriate to give examples from Group 1 and Group 3.

Exemplary Student Case 1

Onurcan Onal was in Group 1, and he developed his idea from the BSA exercise throughout the project phases. He stated that this exercise created a starting point for idea-generation. He developed his BSA outcome on *adapt* and *attach & detach* further in every project phase, and presented his final design idea with a natural inspiration source. He mentioned BSA was a useful tool, with the use of strategies from nature and the stages following each other in a logical sense. His use of the BSA outcome throughout the project phases are shown in Figure 2, 3 and 4.

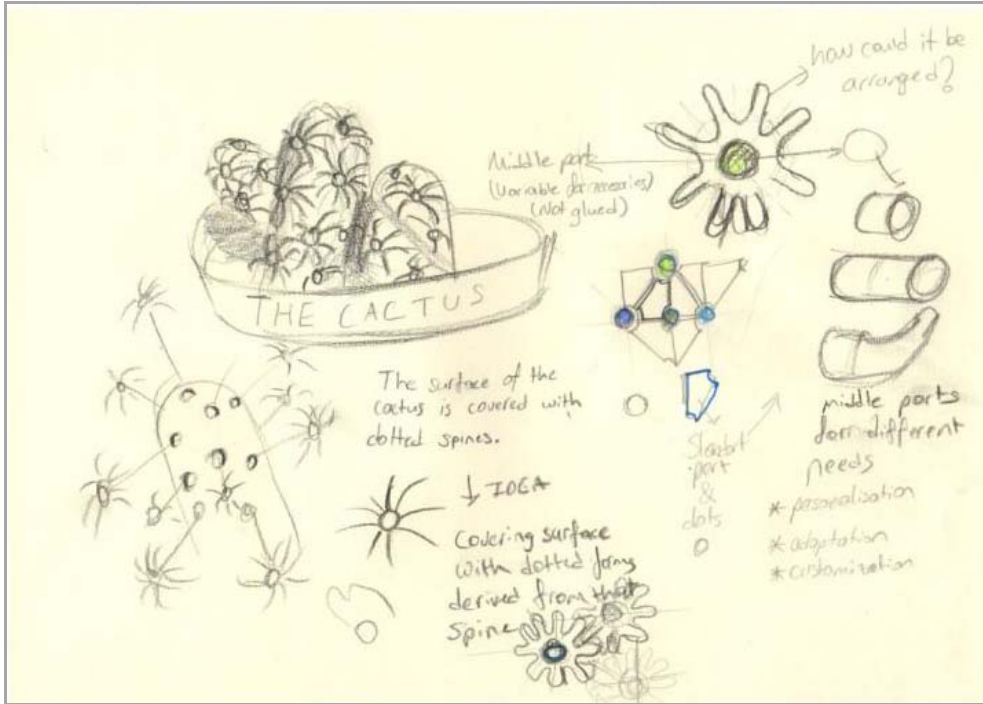


Figure 2 - The BSA outcome presented by Onurcan Onal.

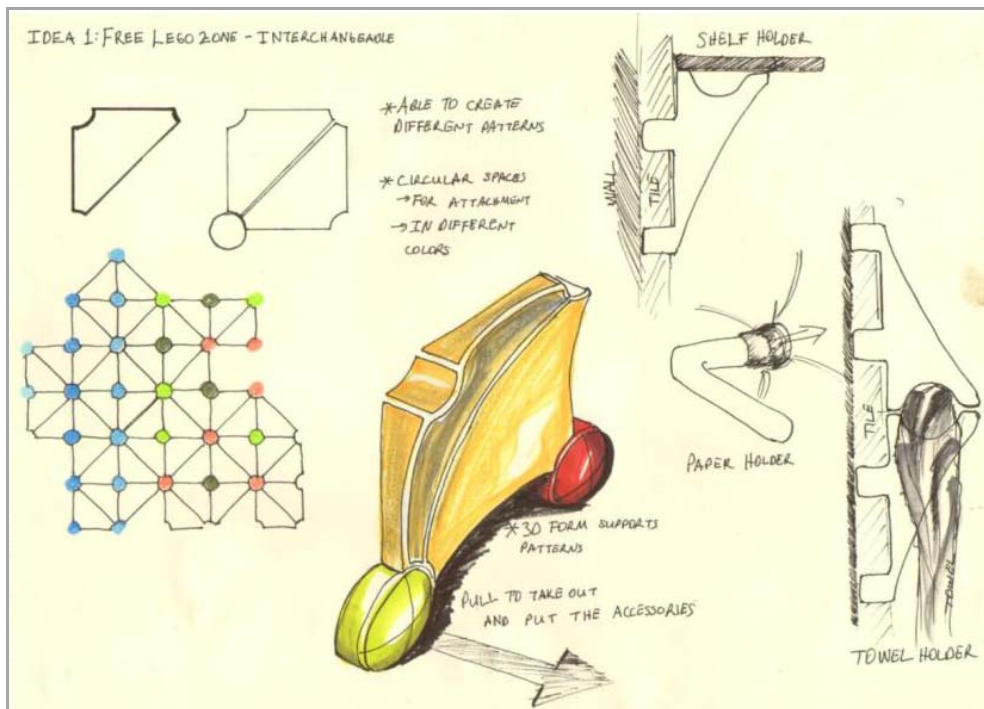


Figure 3 - An outcome from the design detailing phase with a focus on personalization presented by Onurcan Onal



Figure 4 – Preliminary jury presentation board by Onurcan Önal.

### Exemplary Student Case 2

Fulden Dehneli was in Group 3, and she developed her BSA outcome throughout the project phases. She stated that she was not content with her BSA outcomes in general, except for the one that she developed that showed considerable potential regarding the project considerations. She pointed out that the strategies from nature were helpful in finding inspirations sources. She also stated that the biomimicry approach could be used only in some design projects without giving any specific product categories. Her use of the BSA outcome can be observed in Figure 5, 6 and 7.

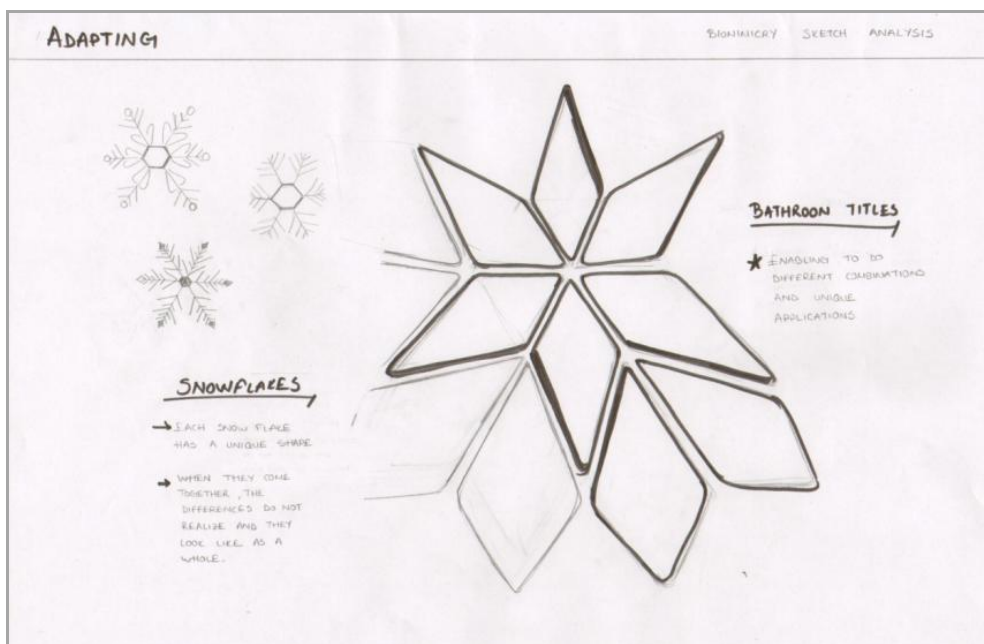


Figure 5 - The BSA outcome presented by Fulden Dehneli

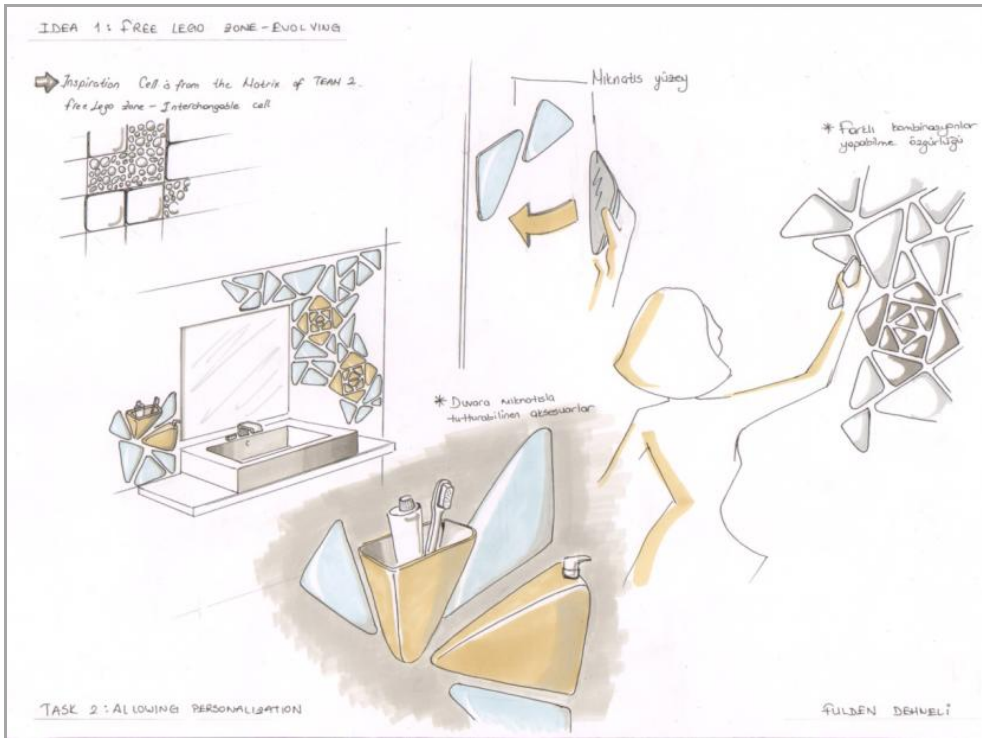
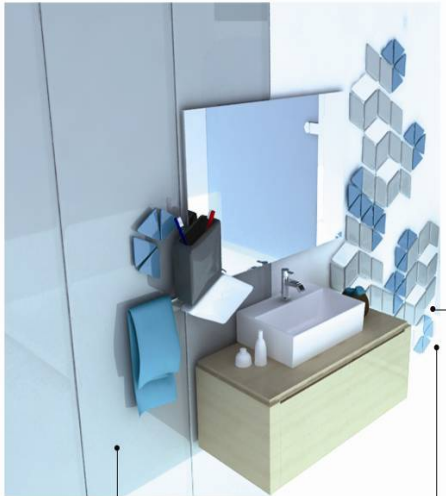



Figure 6 - An outcome from the design detailing phase with a focus on personalization presented by Fulden Dehneli.

## MAGNETILE



Sinterflex tiles are used for background



Magnet tiles which are bonded to magnetic sheet have different shapes and that enables to personalize bathroom in various ways.

Magnetic sheet is put on sinterflex tiles and hold magnet tiles on its surface.


Metal bar carries the towel and accessories which are liquid soap dispenser and toothbrush holder.

### Personalization


There are three different shapes which can come together in different ways. Thanks to this, it is possible to make unique combinations.

Besides that, changing colors by painting the tiles, personalizing can be done.

Also, Magnetile can be thought for not only new bathrooms but also the old ones.



### Fun for Children



The puzzle like forms of these three pieces and instability make Magnetile enjoyable for children.

Kids can create their own combination, while her/his mother designing her bathroom with these tiles.

### Reusing Waste Tiles

Waste tiles in sufficient sizes can be shaped according to these three basic forms.

Thanks to this application, these useless pieces gain meaning and become ready to use for Magnetile.




Figure 7 – Preliminary jury presentation board by Fulden Dehneli.

### Conclusions

Main conclusions from and insights into the design research are as follows:

- Individual conduct of the exercise allowed easier application of the exercise, encouraged different perspectives of the individuals on inspiring from nature and its models to emerge, and increased the number of ideas developed.
- To improve BSA, the students suggested more allocated time, the use of other sources (e.g. online databases, documentaries, biology books, etc.), and a class exercise done collectively for the observation and the analysis stages. More allocated time along with design critiques for better quality outcomes was emphasized for the transfer stage.
- BSA exercise was affective for assessing the integration of the biomimicry approach as it created awareness about biomimicry, and provided assessment criteria on how it should be incorporated in achieving sustainable design considerations. The exercise also led the students towards observing natural inspiration sources through the selected strategies from nature in line with the sustainability considerations.
- It constituted a transition stage between research and idea-generation phases of the design process, by incorporating both. Half of the students presented their final designs inspired and informed by nature. The number of ideas developed as a result of BSA (i.e. 118 ideas) was influential, as it created a pool of ideas for the students to reflect upon.
- From the instructors' points-of-view, the BSA exercise was found effective at the idea-generation phase, even though the duration of the exercise was short considering the project schedule. Defining and incorporating the strategies in the BSA at the beginning helped the students find inspiration sources. Taking photos of inspiration sources was found useful, yet alternative ways of documenting (e.g. logbooks, audio and video recordings, etc.) were suggested to have a better understanding of the process.

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# Objects Of The Forest: An Experimental Design Expedition In The Amazon Region

Andrea Bandoni

Conceptual Designer and Design Consultant

Rua Antônio Carlos 196, 94A

CEP 01309-010 São Paulo SP

Brazil

## Abstract

The Amazon Forest is an immense territory to be explored by designers in order to provide new and more sustainable references. 'Objects of the Forest' is a first attempt to head in the direction of discovering design potential in areas dominated by nature, so that new methodologies for creating sustainable objects can be derived.

## The Amazon as a new territory to be explored by designers

### Context

The fact that our world nowadays is over-saturated with objects, images and symbols, in addition to the big amount of waste that we produce, is leading designers to review their social role. That is because the finishing of the planet's resources puts into discussion today's product manufacturing system, the procedures rooted in the industrial age in which designers play a role:

*Resources are extracted from the earth, refined, formed into parts and assembled into products using mass-production processes; they are then widely distributed, sold, used, discarded and replaced. This system, which has become increasingly automated over the years, is mainly unidirectional in terms of its flow resources and energy. (Walker 2005)*

*The transition from the folk arts to the world of professional design is a transition of process. It is usually accompanied by a 'distancing from' the intimacies and nuances of place, space, materials, and many of the ingredients of an authentic, visceral experience of the world. This removal of awareness through process can be seen as a contributing factor in the development of many unsustainable practices associated with modern manufacturing; practices such as labor exploitation and pollution production, which are so insensitive to the realities and needs of people and the natural environment. (Walker 2005)*

The strong focus on nature that we experience today in the design field relates to the search for new and more sustainable references, which could point towards alternatives to deal - and possibly change - the current manufacturing system. Just like natural scientists, a lot of designers are getting closer to nature in order to identify opportunities, discover new materials, textures and processes, rethink the use of resources and produce more adequate and representative designs of our times.

*Since 1990 there has been a notable renaissance in Nature Design, expressing itself in a wide range of forms and functions. Design oriented on nature seems to acquire relevance whenever modern society finds itself in crisis as it searches to re-establish a harmonious relationship with an environment perceived as out of balance or hostile (Sachs 2007:229)*

According to Braungart and McDonough, it is the designer's role to imagine a new, post-industrial logic, considering not only how we can use materials without harming people and the environment, but go beyond and mimic nature, creating a system in which products have a positive impact on the planet. Through their perspective, designers can defuse the environmental crisis by helping people to live more sustainably through design decisions.

*It represents one step toward a radically different approach to designing and producing the objects we use and enjoy, an emerging movement we see as the next industrial revolution. This revolution is founded on nature's surprisingly effective design principles, on human creativity*

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*and prosperity, and on respect, fair play and good-will. It has the power to transform both industry and the environment as we know them. (Braungart & McDonough 2002:6)*

### The Amazon

Inside this international design movement towards considering nature's models and materials as objects worth of investigation, the Amazon Rainforest emerges as an immense territory to be explored by designers. The main interest of Amazon for the design field relies on the potential of its biodiversity.

*One in ten known species in the world lives in the Amazon Rainforest. This constitutes the largest collection of living plants and animal species in the world. (Wikipedia 2012)*

The geographic isolation of the area also enabled the development of a specific local culture, which has a strong relationship to nature and is not known in many aspects. The powerful presence of nature in preserved areas definitely has an influence on how people manage natural elements on a daily basis.

There are many registers of expeditions in the Amazon in fields such as anthropology, biology, geography, history, etc. However, a designers' approach leads to specific questions that other fields do not consider, since it aims to find present and future opportunities to our material culture.

Is it possible, that in the beginning of the XXI Century, one can live in symbiosis with nature, using natural elements consistently in daily life? How to approach and discover local and inspiring designs and materials in such a huge area, identifying its cultural, conceptual and aesthetical values?

### Objects of the Forest

#### Goals

"Objects of the Forest" ([www.objetosdafloresta.com](http://www.objetosdafloresta.com)) is a project awarded in the end of 2011 with subsidies from the Ministry of Culture of Brazil (Programa Rede Nacional Funarte de Artes Visuais). It proposed to identify and diffuse existing design solutions that merge culture – human, rational processes – with nature, to be found in the Amazon region.

The inspiration for this project is an object called "tipiti". This is a tool created specifically for processing cassava, one of the basic food staples in the Amazon region. It consists in a sort of squeezer made of the straw from local plants, used to separate liquid (water and poison) from the solid part of the cassava. It actually enables the once dangerous and lethal plant to become a nutritious and lifesaving food source. The appearance, texture and function of this artifact helped to realize that in an area with dominant nature, where the existing relationships between men and environment are visible and materialized into objects, a lot of references could be found and revealed to the world.

The richness of the Amazon Forest was never before explored solely under the design point of view. As an experimental proposal, "Objects of the Forest" had the following goals:

- register and spread design objects that are representative of the material culture associated to the reality of the Brazilian Amazon Forest, in sustainable ways. Point on these daily sustainable objects their conceptual, cultural and aesthetical values.
- enable local designers and artists to observe objects under a conceptual point of view and to approach the Amazon Forest with a new mindset.

Ultimately, the project intends to foster the design of contemporary objects which have a total connection to nature, respecting its cycles without generating any production waste. In this sense, it follows the cradle-to-cradle philosophy, specifically engaging with a closed loop in the so called biological cycles.

### Methods

The structuring of this project was not based in any specific methodological reference. To systematize the initial proposal, three interrelated fronts of execution were organized:

#### 1. Exploratory Journey

It consisted in the trip of a conceptual designer trained with strong sustainability focus to the Amazon, lasting approximately one month (April 2012). With the support of other professionals, objects that have a unique relationship with nature and that are representative of the local material culture were collected and registered. Visits to strategic locations pointed out by existing entities and by previous research were planned, but improvisation was also considered and allowed. The development of the journey, in all details, could be followed through an online diary, which is permanently available on the project's website.

#### 2. Local Workshops

There were two free workshops, in the two main cities of the Amazon, Manaus and Belém. The goal of the Workshops was to discuss sustainability at a local level and to empower Amazonian artists and designers to seek creative possibilities in nature, understanding objects under a conceptual bias, and approaching the Amazon Forest under a new perspective. To achieve this goal, it was important that the workshop program was open to the participant's suggestions, and also that there was no hierarchy in the dynamics – the workshop facilitators also produced projects, as any participant.

Besides going to the Forest and getting their hands dirty, the participants were encouraged to stay connected and continue the discussion, creating a network. Whilst the collaborative workshops elaborated on the fundamental issues debated nowadays, they valued not only local culture and nature, but also the local professionals.

#### 3. Publication

The selection of objects resulted in the e-book "Objects of the Forest" ([www.objetosdafloresta.com/download](http://www.objetosdafloresta.com/download)).

It presents a selection of objects found in the Amazon, which under the design point of view tell compelling stories about the coexistence of man and nature. The whole project and the workshops are also reported in the e-book.

The publication is bilingual Portuguese-English, and it has a format that allows basic printing in A4 size. The e-book was strategically chosen to be the final product of this project for several factors, namely:

- Democratic:  
easy to find and access, in the case of this project it is available online for free download.
- Portable:  
it can quickly be transmitted over the Internet, or simply transported on CD or pen-drives.
- Inexpensive, without loss of quality:  
As its production and delivery costs are lower, a high-end digital book can get to the reach of the reader for free.
- Inclusive:  
There are softwares that can read books aloud, or even create audiobooks, converting the reading on a sound media.

### Findings



Some of the Objects of the Forest.

There were several artifacts worth of investigation found in the expedition. The selection for the publication took into account its aesthetical, cultural or social expressiveness for a contemporary debate on design. The elected published objects reveal an impressive richness, with an inherent sustainability: it is possible to sight nature, its cycles and processes through them. Whether each object has a few studies or is recognized as a cultural heritage, they all are shown to be used in the XXI Century, proving the timeless character and the value of solutions often regarded as “primitive”. The connection most of them posses with an ancestral indigenous culture is explicit, hence the importance of ensuring their preservation. This is a sample of objects reported in the publication:

- *The Pirarucu is a giant fish, one of the most well-known of the Amazon, measuring on average two meters long. (...) Once dried, the bone of the Pirarucu’s tongue acquires the texture of a rough sandpaper, and measures approximately 20 centimeters in lenght. It is used to grate Guaraná sticks into powder. (Guaraná is an amazonian fruit known for its energizing properties, and the stick is the oldest form of retaining and trading this product). In keeping with the tradition of using every part of the Pirarucu, this object also appropriates part of the animal and turns it into a domestic utensil.(...)*
- *The object consists in the appropriation of a part of the palm tree whose function is to protect flowers and fruits. It is called spathe or bract, and it resembles a large petal. (...) When it falls from the tree and dries, it becomes stiff and can be used by people. This is an extremely versatile natural shape, able to generate movement and suitable for several uses when appropriated: as a fruit bowl or receptacle, a decorative object or even as a swing or cradle for children. These are customs inherited from indigenous cultures.*

Most of the objects depend on natural conditions and are at many times perishable; rooted in a non-consumerist culture and derived from techniques that survive from artisanal practices often endangered. When working with this selection of objects, any attempt to group the objects was always insufficient. For example, when objects were separated into furniture, toys, tools, etc. the ones that have multiple uses or are open to improvisation couldn’t fit. Due to these obstacles, usual “manufacturing categories” were left aside so that we could dive authentically into the relationship of objects and nature, leaving the observer scope for association.

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Through the journey it was possible to observe the richness of the forest culture, as well as the loss of it. Not only the forest is vanishing: as the local culture absorbs our industrial patterns of consumption, the local habits change and the knowledge about nature and the forest seem to gradually disappear. Seeking a “western” way of life, younger generations reject and loose their traditions. The research on the objects confirms this situation:

- *For a long time this was a means of survival in the Amazon. Today, with the diminishing number of traditional flour production houses, the use of tipiti is dwindling, and the knowledge of this object's production is gradually lost. The tipiti today is encountered mainly seen as a souvenir, available in different sizes.*
- *The habit of using natural materials as packaging is disappearing in the Amazon region. For example, fresh meat was formerly wrapped in sheets of Arumã leaves in the markets, but today is being wrapped in newspapers or even plastic bags.*

## Opportunities and Follow ups planned

### Resource Efficiency, Lifestyle, Innovation

The project research brought unique references about a connection to nature that can exist through objects. As these objects show clearly their cycles, their processes can be easily understood, so that people develop an awareness about the logistics of natural resources and care more about the maintenance of a new, sustainable system.

The objects also call attention to a lifestyle that is vanishing. It doesn't mean that it is also the designers' role to save these objects from being extinct. Nevertheless, the objects highlight the fact that the sustainable world is different from the current, since it is not industry-based - something hard for us to imagine. Moreover, it is up to us designers and planners of the future, how to build it.

*Taking an eco-effective approach to design might result in an innovation so extreme that it resembles nothing we know (...). It's not the solution itself that is necessarily radical, but the shift in perspective with which we begin, from the old view of nature as something to be controlled to a stance of engagement. (Braungart & McDonough 2002:84)*

In the search for sustainable sources of inspiration that can consistently be applied to the contemporary world, given the changing panorama found in the Amazon, first of all there is an urgent need for the design field to discover and explore the uses of existing materials and techniques in this region. It is also important that a more conceptual look is taken upon the prospects opened by these elements, so that they become attractive to the eyes of local younger generations.

The great amount of resources worth of attention found in the area will definitely require diverse design experiments, which should consider not only techniques, but also the existing cultural relationships. The best way to develop this knowledge would be through the work of local designers, since it would not only keep them employed in an important mission, but also enable the sustainable growth of the region.

However, through our research, it became clear that although local designers exist and they are willing to take sustainability into account, they still miss a lot of skills. Instead of experimentalism, the most common attitudes found were “copying” and “repeating”, in which external approval count more than local intuition or knowledge. It is also more usual to “wait” than to “propose”, this being a cultural mindset of Brazilians, who are starting to adapt to an entrepreneur-based age.

It is very special the fact of creative and active people living in the Amazon; they should be aware of their importance of being in this context and be encouraged to innovate and assume a transforming role. Local designers should be, then, trained to take more conceptual and experimental approaches, learning how to research in more independent and pro-active ways. Work methodologies of globally connected designers needs to reach them, so that it boosts their confidence and help them innovate with sustainability. In a following stage, these Amazonian designers can start to find new markets and eventually set new patterns of production and consumption.

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The project 'Objetos da Floresta' passed through 9 strategic locations, encompassing communities, design schools and various organizations. The visit to more than 30 institutions plus the workshops in the two main cities, with a total of more than 50 participants, initiated a connection that is being feed, especially through an online social network.

This network is a step towards connecting local people (designers, artisans, researchers) and possibilities (materials of the forest, ancient techniques) to a wider audience, with collaborators in the same or related fields. It is the project interest, in following phases, to improve and develop a consistent open network. It should expand to a system in which we connect local and global people to help each other or even work together in precise contexts, having the sustainable focus in mind.

In partnership with local Amazonian institutions, the network can keep a material and process library with local findings. There's strong potential in developing it into a design organization, always assuring that the sources of information and inspiration remains with easy access and open for new insights.

This project aims to lay foundations to enable the creation of ambitious design solutions for the future, which in fact reinvent the world we live in. It's experimental and innovative methodology can not only inspire designers to make research aiming to envisage new alternatives for sustainable design, but it can also serve as a model of interaction with territories where, although there is potential, design is less explored. The clear diffusion of its results and the development of its network can definitely mobilize or serve as case study for similar projects in Brazil and around the world.

### Acknowledgment

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## Let's Start With The Rest!

Frank Becker

Scientific Staff

Technische Universität Berlin, Science Shop kubus

sec. FH 10-1, Fraunhoferstr. 33-36, 10587 Berlin

Germany

Johannes Dietrich

Scientific Staff

ZeroWIN project

Technische Universität Berlin, Science Shop kubus

sec. FH 10-1, Fraunhoferstr. 33-36, 10587 Berlin

Germany

Karin Zacharias-Langhans

Director of Inligna

Inligna

Swinemünder Strasse 110/111, 10435 Berlin

Germany

### 1. Abstract

Resource productivity and efficiency in production and consumption are moving up the global agenda. But are they adjusted to reach the goal of GHG reduction and global warming in fact? It might be the fact that – driven by several rebound effects – the global climate regime failed already in the beginning and that green growth is a stark utopia. Putting together sustainable entrepreneurship with post growth economy can put an end on greenwashing.

Sustainable innovation has to include strategies of sufficiency, consistency and efficiency. Given this thesis, the development of business models and “towards zero waste” enterprise concepts focused on resource recovery by reuse and further use of goods are core to sustainable innovation.

Transdisciplinary participatory projects have delivered profound results that concepts of sustainable innovation, resilience and transition have to start with left over semi-finished goods respectively used goods: The process of sustainable innovation has to incorporate left over or semi-finished goods respectively used goods as well.

### 2. Initial situation

There is a tragedy about harmful impacts of climate change and the negative societal outcome of economic activities of highly developed countries on display on nowadays world stage. Although depletion of fossil fuels and exponential economic growth have been identified as key causes of this tragedy, there is still a lack of sustainable solutions. Especially solutions that tackle and successfully combine the economic and the personal life spheres are still missing (cf. WBGU 2011, Meadows et al 1992).

The complex causes of climate change require relatively direct, practical, applicable and easily transferable solutions (Becker & Dietrich 2011). According to WBGU, it is about changing a paradigm with creating a new basis for economic processes concerning production, infrastructure, lifestyles, regulatory systems and the interaction of politics, society, science and economy (WBGU 2011).

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There is a widespread feeling of helplessness given the fact, that the goals of decreasing CO<sub>2</sub> emissions and limiting the socially and ecologically compatible rise in temperature cannot be combined with the expectation of growth in industrial development (WBGU 2009). This sensation is backed up by statistics showing an effective global increase in CO<sub>2</sub> emissions of 40% since 1990 (Figure 1, Jackson 2009).

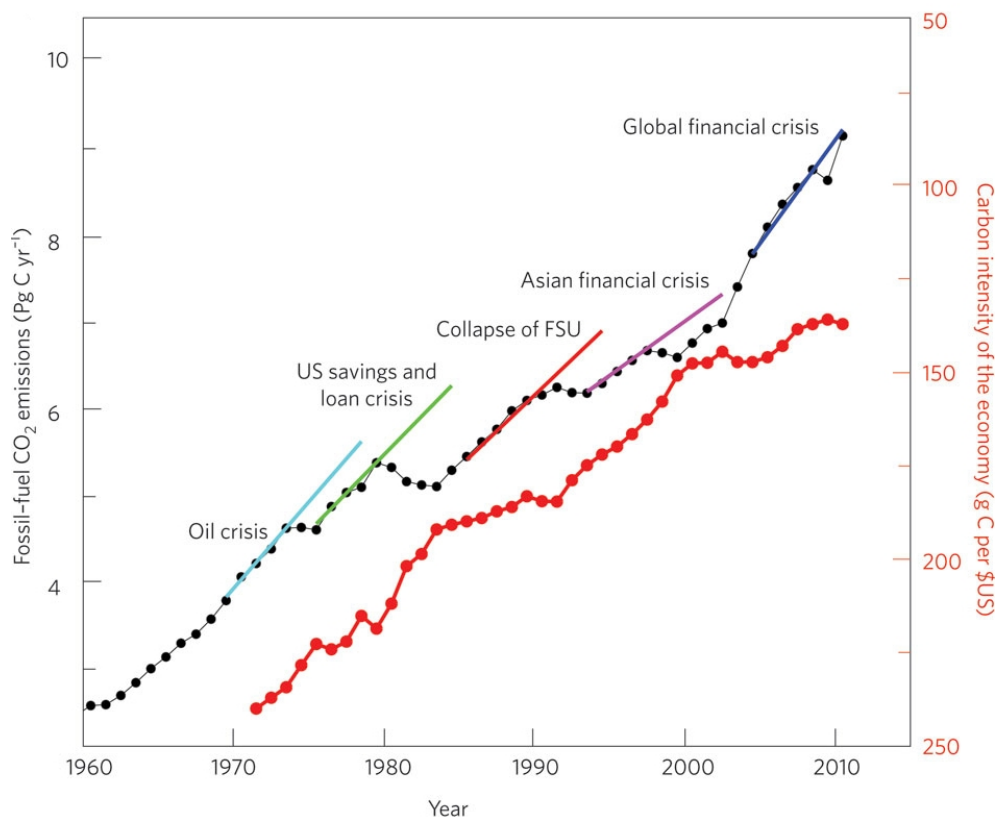


Figure 1: Global CO<sub>2</sub> emissions and carbon intensity (Peters 2012)

Emissions of CO<sub>2</sub> from fossil-fuel combustion and cement production for the world (Pg C yr<sup>-1</sup>; black curve) and the carbon intensity of world GDP (g C per \$US (2000); red curve, inverted axis). The most important recent financial crises are highlighted with a linear trend fitted to the five years before the beginning of each crisis. Pg = Petagramm - one Billion ( $10^{12}$ ) kilogramme

### 3. Examples

#### 3.1 LifeLine Soap – Promoting the integrated use of wasted resources

LifeLine Project is a community led campaign promoting the integrated use of urban resources (people, places, and materials, systems) to achieve enhanced efficiencies and well-being. The inquiry focuses on Northwest inner city Dublin as a living laboratory for sustainable innovation. Project interests include local food systems, urban biodiversity, green transport and innovative models of healthcare, and waste management.

<http://www.communitylinks.ie/students-learning-with-communities/projects/lifeline/>

This LifeLine artisan soap is hand made and contains over 50% premium ingredients sourced locally. These include organic herbs grown on organic kitchen waste and oils discarded by a local food production company. The company imports high quality food products (olives, sun dried tomatoes) in oil which is poured at the point of sale. This high quality oil cannot be reused for food production due to health and safety regulations.

By using these oils in soap making the LifeLine Project helps the enterprise to meet its legal requirement to divert these oils from landfill. Using the discarded oil saves money, allows investing in ingredients that enhance the soap's therapeutic qualities. Because the oils are of a better grade than commonly used in soap making the end product is superior to most commercial products. This



process is an example of sustainable innovation, when one industry's waste becomes a valuable resource for another.

### 3.2 Resource Exchange Platform (RXP)

The EU-funded project ZeroWIN – Towards Zero Waste in Industrial Networks ([www.zerowin.eu](http://www.zerowin.eu)) aims to establish industrial networks that make waste history by reusing and recycling residual materials from different industrial sectors in regional material cycles.

For that purpose a Resource Exchange Platform (RXP) has been developed in the course of ZeroWIN to enable the exchange of used goods and left-over materials. The platform has originally been designed to exchange used ICT products within the association network “ReUse-Computer“, based in Germany / Berlin. It is now being implemented in one of the largest Berlin enterprise networks including all industrial sectors and will come up the base of a European Business Network<sup>1</sup> and will enable sustainable innovations (Figure 2).

**resource-market.eu**

Germany, UK, France

Overview Products Request Search RXP logout

**Products**

- || Add Product
- || List of Products
- || Sale
- || Rental
- || Inventory
- || Products to edit
- || sold products

You are logged in as:  
**UP**

**Products sale**

Only show my products

ID	Type	Price	Category	Owner				
34	UP Umweltanalytische Produkte GmbH MfRo-MX	1.00	Datenlogger	UP Umweltanalytische Produkte GmbH	🔍	✓	✗	📄
38	UP Umweltanalytische Produkte GmbH ADL-MX	1.00	Datenlogger	UP Umweltanalytische Produkte GmbH	🔍	✓	✗	📄
72	Delta-T Devices Ltd DL2e	1.00	Datenlogger	UP Umweltanalytische Produkte GmbH	🔍	✓	✗	📄
485	DL2e	2500.00	Datenlogger	UP Umweltanalytische Produkte GmbH	🔍	✓	✗	📄
489	dI2	2300.00	Datenlogger	UP Umweltanalytische Produkte GmbH	🔍	✓	✗	📄
495	4r344rr	23423.00	Widerstandsmessung	UP Umweltanalytische Produkte GmbH	🔍	✓	✗	📄
496	4565-jk9	656.00	Datenlogger	UP Umweltanalytische Produkte GmbH	🔍	✓	✗	📄
521	DL2e	1500.00	Datenlogger	UP Umweltanalytische Produkte GmbH	🔍	✓	✗	📄

Figure 2

To give a practical example, monitors, no longer suitable as ICT units, can find secondary use as signage in the construction industry<sup>2</sup>. Pallets can gain a second life as planting boxes or printing blankets can be used to cover roofs and outdoor furniture.

Given the 306 Million PCs and Laptops sold worldwide in 2009 (N24 2010) and with respect to the worldwide PC shipments of totally 89 million units in the first quarter of 2012 (Gartner 2012) we can assume about 50.796.000.000 kg CO<sub>2</sub> emission by the production of ICT in 2009.

Besides environmental benefits, the RXP enables social (e.g. inclusion of marginalised people) and economic (money savings, employment) benefits. Third sector organisations such as social enterprises and not-for-profit companies are involved in an enterprise network for repair, refurbishment and reuse of products and materials. This example leads to broader definition of sustainable innovation, including social, economic and environmental aspects.

### 3.3 .hikk – Wood in CreativeCycle

The Berlin Wood in CreativeCycle – hikk [Holz im KreativKreislauf] project (<http://hikk.mixxt.de>) deals with the use of rest-wood of carpentry-shops and has delivered the Lotta Rest (Figure 3) business

<sup>1</sup> Ongondo, F.O., I.D. Williams, J. Dietrich und C. Carroll: TOWARDS REUSE NETWORKS FOR ICT: EXPERIENCES FROM THE ZEROWIN PROJECT. Tagungsband des 13. International Waste Management and Landfill Symposiums, Sardinien 2011.

<sup>2</sup> Hickey, S. et al.: Implementation of Design Recommendations in High-tech Products: D4R Laptop (Case Study 1). In: den Boer, E. und M. Wolf [Hg.]: Concept Papers for All Networks/ Pilot Applications. ZeroWIN Project Deliverable 6A.1.1, 2011.

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model for the production and marketing of small furniture and accessories. As shown not only in these projects the further use and extended use of residual and used goods has a huge impact as well on reducing GHG emission and resource recovery as on societal socio-economic development and cohesiveness. There are not only discrete results: these results can be conceptualized towards a model for sustainable innovation. The .hikk project addresses questions of adapted economic exchange opportunities.

Approximately 440 m<sup>3</sup>/month of useable rest wood is accumulated in 125 carpentries located in the Berlin district Pankow , currently used for thermal utilisation. Assumed an equivalent of 585 kg CO<sub>2</sub> per m<sup>3</sup> chipboard the respective possible savings of GHG by further use are about 257.400 kg CO<sub>2</sub> / month. Based on mainstream economics the reuse of this rest wood is uneconomic to the carpentry shops: new professional chipboard costs about 7,- € / m<sup>3</sup>.

From this point of departure .hikk outlined a pilot for cost-efficient collection, storage and re-utilisation of leftover wood. It is used cooperatively for creatively designed products from leftover wood for batch productions. Corner stone is Lotta Rest, a modular multifunction cube, useable as stool, rack or table.

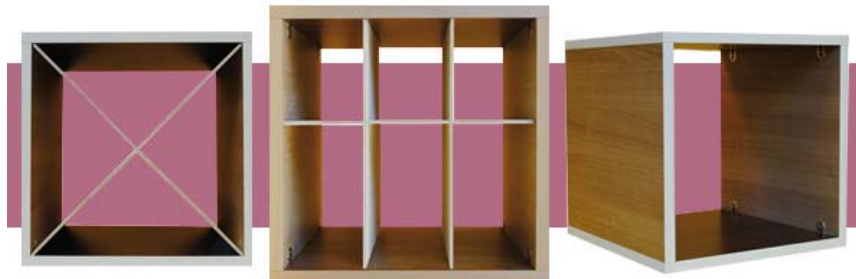


Figure 3

In the course of these different projects the authors developed the value conservation concept (Becker 2008). This value conservation concept, visualised by these examples can be incorporated in local transition initiatives on district level in Berlin and transferred to other cities / regions. The authors intend to share these results for the benefit of sustainable innovation towards resilient societal development. Rethinking sustainable design in a way that starts with the material – rest wood, used ICT and other goods – is the starting point of sustainable innovation incorporating sufficiency and consistency focusing an economy adjusted to sustainable development.

### Spaceship economy

The value conservation concept is based on the idea of avoiding production and consumption, as formulated by the economist Kenneth E. Boulding in 1966 in his essay *The Economics of the Coming Spaceship Earth*: “By contrast, in the spaceman economy, throughput is by no means a desideratum, and is indeed to be regarded as something to be minimized rather than maximized. The essential measure of the success of the economy is not production and consumption at all, but the nature, extent, quality, and complexity of the total capital stock, including in this the state of the human bodies and minds included in the system. In the spaceman economy, what we are primarily concerned with is stock maintenance, and any technological change which results in the maintenance of a given total stock with a lessened throughput (that is, less production and consumption) is clearly a gain.

This idea that both production and consumption are bad things rather than good things is very strange to economists [as well to engineers as to designers], who have been obsessed with the income-flow concepts to the exclusion, almost, of capital-stock concepts.” (Boulding 1968)

[http://www.eoearth.org/article/The Economics of the Coming Spaceship Earth \(historical\)#](http://www.eoearth.org/article/The_Economics_of_the_Coming_Spaceship_Earth_(historical)#).

The referred value conservation concept owes much to the paradigm of the spaceship economy.

### 4. Creativity – it's not only about Design

The lesson to learn from the examples presented is about rethinking the developing process on the whole: Function and form follow residual. It would be a misconception to identify innovation (only) with novel and sustainability with efficiency. There are some serious shortcomings in the discussion. We should start asking “efficiency – for what?” (Gross Stein 2002), if we want to get access to new concepts of sustainable innovation. This can be illustrated by the following examples.

#### 4.1 The Recycling Design prize

<http://www.recyclingdesignpreis.org/en/recyclingdesignaward-2012/>

Since 2007 the RecyclingDesignprize is advertised by the German RecyclingBörse. This recycling design award is an open competition. All creative's and designers with professional or semi-professional education can submit there objects or designs.



Figure 4 Submitted object of the RecyclingDesignprize 2011

Through the use of „discarded things“ - such as remnant material from industries and manufactories, „rubbish“ - seemingly useless things should be made usable again. Bearing in mind the social criteria these products thereby developed should be sold also by job creating organizations or social enterprises. The production of “clever”, “beautiful” and “useful” designed objects which awarded a prize conduces to the environment and is a contribution for employment promotion. The range of required developments stretches from decorative articles, furniture, clothes/textiles, to various other accessories.

The objects and articles must be designed and made out of garbage and/or residual from industry and manufactories for our everyday use or to be used for decoration and furnishing.

#### 4.2 .hikk vermöbelt

In 2012 BAUFACHFRAU Berlin e.V. advertised the .hikk vermöbelt Design Award the first time. It focused on the further use of rest wood of carpentry shops. Young talents of vocational training schools and colleges of Art, Design and Wood were invited to create an innovative and sustainable small piece of furniture or accessories prototype.



Figure 5: First Price of .hikk vermöbelt 2012

Rest wood is aggregated in great quantities in woodworking shops. It is especially for the matter of wood-based panels, e.g. chip board, MDF- or multiplex board.

The specification of the competition was to deliver a creative and innovative product idea made of 80% rest wood minimum. There was a presetting of quality (one of the three referred types of wood board) and quantity (cir. 1,2 sqm.) of rest wood defined in a pre-cut plan.

## 5. What's Next?

### 5.1 Making Use of ReUse

The next step might be the planning, managing and evaluation of a business start-up competition "transform Europe – making use of ReUse". Only if actors for sustainable development are mobilized and supported, a radical transformation is possible. It especially needs start-ups that can and want to act radically sustainable, free of existing concepts.

Students/graduates from universities, arts and craft colleges, and vocational training schools could participate in such an international business start-up competition. Business start-ups that innovatively facilitate the re-utilization of material will be awarded. The winners of the competition should be supported in transferring their chosen field of business into practice. Therefore, they will receive consulting by experienced and committed sustainable entrepreneurs in regard to results, experience and tools.

The internet-based RxP-platform mentioned before e.g. could be used as a Europe-wide portal to allow participants to down- and upload applications. Moreover, they might receive support through the platform.

### 5.2 Resource Recovery

Based on the presented project results and the results of the Participatory Sustainable Waste Management project (Tremblay & Gutberlet 2010), the authors have conducted a transnational (Brazil – Canada – Germany – Morocco) RESOURCE RECOVERY workshop on the University of Sao Paulo / Brazil in September 2012. It led into preparation of an international research project. Benefits are expected in generating knowledge relevant to action and developing sustainable innovation concerning product development, creating businesses and developing societal resilience on local, regional and national level.

The workshop began to show that the scientific education as well of engineers as of designers has to incorporate skills of optimizing, refurbishing, up scaling as normally as designing artefacts from new resources. The workshop led up to the necessity of rethinking this process as a whole: Some catadores (Brazilian waste scraper) showed up that it is as well needful as possible to redesign this scientific education based on the mutual knowledge of catadores. This is an open question to many

Universities and study courses, initiating transdisciplinary participatory projects can lead to profound results.

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## Green Business Model Innovation: Definition, Next Practice and Nordic Policy Implications

Tanja Bisgaard  
Founder Novitas Innovation  
Virumgade 48c, 2830 Virum  
Denmark

Kristian Henriksen  
Special Advisor  
Danish Ministry of Business and Growth  
Folkvarsvej 10, 4. th., 2000 Frederiksberg  
Denmark

Markus Bjerre  
Head of Section  
Danish Ministry of Business and Growth  
Blomstermarken 21, 2860 Søborg  
Denmark

### Introduction

The increasing scarcity of resources in the World implies new business opportunities and new markets for many companies, but it also implies challenges for companies which do not change their way of doing business. Both market leading firms and start ups around the World are increasingly acknowledging that they can get a competitive advantage by increasing their resource productivity or address new markets and customers through new products or services. Traditionally, when we think of green companies, we commonly think of green technology-focused companies such as cleantech companies producing windmills, solar panels energy efficient pumps etc. However, some companies are in addition to this green focus on products, embracing new more 'radical' green innovative ways of doing business such as cradle-to-cradle, industrial symbiosis, performance-based sales etc., leading to more substantial changes in their business model or value chain which again may change consumption patterns, design processes etc. We call it Green Business Model Innovation.

When a company is changing its business model it is altering different building blocks of its business model. But as all the building blocks in the business model are interlinked, a single change of one element of the business model will in most cases affect one or more other elements of the business model. Business model innovation can thus be regarded as system thinking, where there are cause and effect inter-linkages that change over time<sup>1</sup>. In order to succeed in achieving these transformations, companies must move away from thinking in "silos" and employ methods such as design thinking which enable cross-disciplinary teams to work together<sup>2</sup>. Making these types of changes often take a long time since entire systems are altered. Achieving sustainability by making changes in companies' business models will thus require long-term thinking.

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<sup>1</sup> Meadows, 2008

<sup>2</sup> Brown, 2008

Policy makers around the world are, also, increasingly paying attention to how they may support new radical innovative ways of doing business and how policy makers may help companies to disruptive shifts in resource efficiency. Policies are designed to prevent the negative effects of more and more scarce resources, to price externalities appropriately, and at the same time create conditions which can enhance and promote innovation and competitiveness in companies. In our study Green Business Model Innovation for Nordic Innovation we have looked at various policies to support and encourage companies to take on different green business model innovations.

### Defining Green Business Model Innovation

In the literature, there has so far not been established an internationally acknowledged definition of *green business model innovation*, nor has there previously been any structured way of describing these concepts as a whole. There are many terms in the public and academic debate about how companies green their business and how they are categorized as green companies. These terms are ranging from the more product-oriented perspectives like clean-tech companies, to service-oriented companies which provide environmental services, to companies that implement more process-oriented initiatives in their businesses or value chains.

We define green business model innovation as:

*Green business model innovation is when a business changes part(s) of its business model and thereby both captures economic value and reduces the ecological footprint in a life-cycle perspective.*

*Generally, it can be said that:*

- 1) *the more parts of a business model which are changed and have a green effect, and*
- 2) *the more profoundly a green change is taking place within the individual parts of the business model – going from modification, re-design, alternatives, to creation*

*– the greener the business model innovation is and the higher potential for creating radical eco-innovation.*

This is an open definition and it captures many small and large intended or unintended changes in many businesses. It seems problematic to set tighter boundaries on the concept of green business model innovation, since it is not easy to argue for or against why different ways of greening a business should or should not be considered as green business model innovation. However, the more 'interesting' green business model innovations are naturally the ones that radically change the business model and have high economic and environmental impacts for both businesses and society.

In our study we focus and structure the greening of businesses with respect to two main models: the *incentive models* and the *life-cycle models*. The incentive models include models such as functional sales or product service systems and performance-based models which may have green effects such as Energy Saving Companies (ESCOs), Water Saving Companies (WASCO), Material Saving Companies (MASCO), Chemical Management Systems (CMS), and Design, Build, Finance, Operate (DBFO) etc. The life-cycle models include cradle to cradle, take back management, green supply chain management, and industrial symbiosis. All of these ways of doing business have a strong emphasis on green process innovation which of course is complimented by green technological innovations.

### The Business Model Canvas

The business model basically explains how the company is doing its business. The business model explains how value is created for the customers and how value is captured for the company and its stakeholders<sup>3 4 5</sup>. The business model is composed of different elements as captured in the business

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<sup>3</sup> Linder and Cantrell, 2000

<sup>4</sup> Magretta, 2002

<sup>5</sup> Rajala and Westerlund, 2007



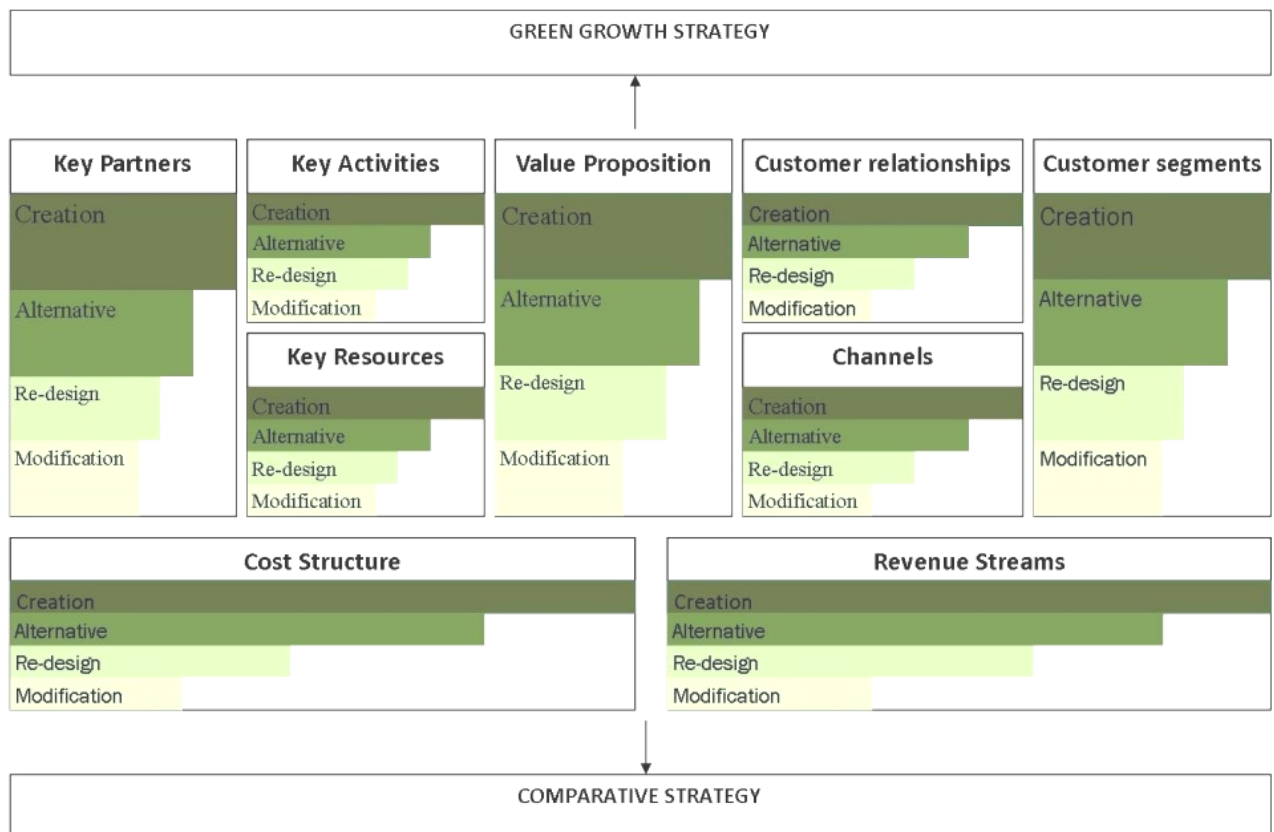
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model canvas tool of Osterwalder et al<sup>6</sup> consisting of nine basic building blocks covering four main areas of a business: customers, offering, infrastructure, and financial viability. The business model canvas can be used to conceptualise green business model innovation. Inspired by the OECD's work on eco-innovation four elements have been added to each of the building blocks in the business model canvas:<sup>7</sup>

- **Modification** through small and progressive adjustments;
- **Re-design** materialised in significant changes;
- **Alternative** building blocks, which can fulfil the same function or operate as substitutes for the original ones;
- **Creation** and introduction of entirely new and innovative building blocks.

Two additional building blocks on comparative strategy and growth strategy have been added based on inspiration from IDEO<sup>8,9</sup> and combined with OECD's work on Eco-innovation, c.f. figure 1.

Figure 1: Green Business Model Innovation



Source: Team analysis, Danish Business Agency 2012

The Green Business Model Innovation framework opens for a number of diverse opportunities for companies to change their business model and it enhances the potential of companies to generate systemic eco-innovation. The framework was used to analyse 41 business cases which primarily had implemented the incentive or life-cycle models.

<sup>6</sup> Osterwalder & Pigneur, 2010

<sup>7</sup> Machiba, 2010

<sup>8</sup> Osterwalder & Pigneur, 2010

<sup>9</sup> IDEO, 2011. The extended business model canvas in the version of IDEO was tested on a workshop. As it is very close to the Osterwalder and Pigneur's business model canvas most of the conclusions from the workshops are transferable.

### Empirical findings

Even though the sample of 41 business cases is relatively small, our analysis based on the knowledge from the business cases can give us a first impression of next practice for companies working with green business model innovation. Many of the companies have employed different types of green business model innovation but only few have so far focused their green business model innovation on both their input side (pre-production and production) and on their output side (use and after-use/reuse).

### Drivers of Green Business Model Innovation

Increased consumer awareness towards sustainability is one of the most important drivers for the companies to initiate green business model innovation. The green agenda has in general been a driver for all the companies – irrespective of the size or sector of the company. The opportunity for companies to differentiate their products and services and create a competitive advantage by being greener and more sustainable than their competitors is another important driver for the companies.

Increasing costs of resources and supply risk is also a driver of green business model innovation as it forces companies to consider alternative resources for their production. Companies need to find ways to cut costs and create new revenue streams by changing or expanding their focus on how to source from surplus materials, design recyclable products, add services to products or create take-back mechanisms for reuse of products or components.

### Barriers to Green Business Model Innovation

Lack of knowledge and skills relevant for applying green business model innovation throughout the entire value chain is one of the most important barriers encountered among the companies. In the development and production phases, employees lack knowledge of what substances are contained in the materials they use, what alternative materials to use and how to use new materials when developing and designing new products. Some customers are willing to buy more sustainable products and services, but there is still a large group of customers without knowledge about sustainability and with conservative buying habits and going for the lowest price.

The large costs of new machinery and new materials or changes needed in new product development and design is another great barrier for companies wanting to make a green transformation of their business model. Furthermore, recycling and reusing materials often require expensive development and implementing of new infrastructure systems.

### Results of Green Business Model Innovation

Many companies' first attempts at green business model innovation are aimed at a limited number of product lines or initial attempts and tests of selling services in a new way. Measuring the outcome is not initially the focus while testing the different ways of doing green business model innovation. However, all of the companies see green business model innovation as a way to create positive environmental impacts, more innovation and financial benefit.

As to the different types of business model innovation, almost three quarters of the interviewed companies have changed their processes, while half of the companies have developed a new service and one third a new product. For some companies the transformation of processes also resulted in new and greener products and services, while some companies experienced that the quest for a new product or service made their processes greener. The more experienced companies working with green business model innovation have combined different kinds of innovation in the entire value chain. But for most of the companies their use of green business model innovation is still at an early stage, and the potential has yet to unfold.

Environmental results might rarely show in the short run because it often takes time for companies to build up and measure the impact of environmental management systems. However, all of the companies in our study have indicated that they in one way or another made or will make environmental improvements because of their green business model innovation. The most commonly

reported environmental effect experienced by the case companies were reductions in raw materials, energy consumption, water consumption, GHG emissions, toxic chemicals and waste.

### Policy recommendations to promote GBMI in the Nordic region

Policy makers' greatest challenge is to ensure that the policies they develop and implement will result in the desired effects. In an increasingly global world, the challenge becomes even greater since national policies cannot always stand alone, but will have to interlink with policies in other countries and regions. Companies can elude local policies by moving their business to alternative geographical locations. This is why it makes sense for the Nordic region to look at policy making in a broader perspective than only national governments.

It is important to understand what types of companies Nordic regional policy should be addressed to. Based on the case interviews completed during this study, it was found that the companies that have taken on green business model innovation are mainly larger companies<sup>10</sup>. While there are cases of innovative small companies, it still seems like the focus of new policy should have a particular focus on assisting SME's in making the necessary transformations of their business models.

### Policy recommendations to promote incentive models

While there is a positive transformation being undertaken in the business community towards more sustainable business models, it is also a journey that can be met with a range of different challenges. Some of the barriers related to transforming a company's business model to an incentive model are large investments that are tied up in products, long payback time for customers and lack of flexibility in the contracts, uncertainty about savings achieved by customers, traditional mindset among customers and employees, and difficulties in involving other companies in the value-chain.

In order to overcome these key barriers, the following policy recommendations are suggested:

- *Encourage an efficient public sector:* Develop selection criteria for the public sector to procure ESCO, DBFO and functional sales solutions when new investments are made or when renovating and operating e.g. public buildings and roads. The selection criteria could be linked to existing standards that ensure sustainability. The scope could also be broadened to include areas such as municipal car fleets, water management or waste management. Selection criteria could be harmonised across the Nordic countries to broaden the scope of bidders in public procurement.
- *Increase flexibility in long-term contracts:* Develop new types of flexible standard contracts for CMS and DBFO business models to make customer less hesitant towards a long-term commitment.
- *Standards:* Ensure that relevant sustainability standards are used for services and processes in all industries where standards have been developed. Standards could be developed for e.g. ESCO contracts that make it possible for customers to evaluate which ESCO agreement gives them best value for money.
- *Nordic financial rating scheme:* Create a framework to establish a Nordic rating agency that can cooperate with banks, pension funds national guarantee funds, venture capitalists and other relevant investors in the Nordic countries to be able to evaluate different types of green business model innovation. The agency should be a private company allowed to operate under licence from government.

### Policy recommendations to promote life-cycle models

Companies transforming their business models into life-cycle models, also meet a series of challenges. Some of the most important barriers are large investments in machinery and infrastructure systems, unwillingness among partnering companies and suppliers to share information on chemicals

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<sup>10</sup> See project's business case compendium for more detailed results.

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and materials, redesign of products and processes to enable the use of new materials, and lack of competencies and knowledge in companies and public authorities.

In order to overcome these key barriers, the following policy recommendations are suggested:

- *Green Public Procurement:* Develop selection criteria based on existing certifications to be used in public tenders, as well as criteria for procuring recycled materials and demanding design for recycling. The public sector can also develop criteria for the resource cycles of companies participating in public tenders. Green public private partnerships can be developed on innovation platforms where problems that need to be solved in the public sector are identified.
- *Infrastructure for recycling:* Promote and develop systems and infrastructures that can encourage the reuse and recycling of obsolete products and materials, as well as infrastructure to handle decomposing of biological materials such as bio-plastics. Regulation can also be developed that requires companies to identify uses for their waste and by-products. Nordic systems should be developed to ensure benefits for all companies in the region.
- *Standards:* Ensure that relevant sustainability standards are used for products and processes in all industries where standards have been developed, and expand to cover more products and industries. The public sector could set these standards as selection criterion in all areas of public procurement. Furthermore, a new type of standard could be developed that tells consumers how their products can be recycled, i.e. plastic, metal, paper or organic.
- *R&D of new materials and chemicals, and access to information:* Support business development with focus on R&D of new materials and chemicals in order to enable new design and processes, for example in partnerships with universities. In addition, provide access to information of new methods in production and the use of new materials and chemicals.

### Implementing policies for green business model innovation

For the policies to be implemented successfully in the Nordic countries, it will be necessary to uncover whether the policy recommendations can be implemented in current frameworks. Existing relevant green innovation funding programs could include or have a strategic focus on the life cycle and incentive models such as ESCOs or C2C.

In addition, more general policies to promote green business model innovation could be implemented in some of these existing programmes as suggested below:

- *Networks and partnerships:* Create business model specific networks for each type of business model, in each of the Nordic countries as well as regionally through regional Nordic networks. Focus areas could be 1) create partnerships between functional sales companies and financial institutions willing to invest in products tied up over long periods while their service is offered to customers, 2) support industrial symbiosis initiatives at Nordic level to drive down search costs for potential companies, 3) develop new skills and competencies in the area of design thinking and systems thinking by experimenting with new types of work teams.
- *Showcases, demonstration projects and dissemination:* The Nordic countries are often considered as a market with customer that demand a more sustainable way of living and have been chosen by companies as test markets for new concepts and products (e.g. Better Place's electrical vehicles). Focus could be on showcasing in certain industries such as building C2C neighbourhoods, or the public sector can develop projects via intelligent public procurement that can be showcased.

### Conclusions

Companies' mindsets are changing and more and more companies are starting to embrace the opportunities of applying green business model innovation. When companies become more efficient and use more sustainable resources they reduce their costs. This is good for business and improves the environmental impact. The increased awareness of green ways of doing business is also becoming a driver of innovation for many companies, where they seek to design new products and services that are more sustainable and improve the processes in their company and throughout the entire value chain using green business model innovation.

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## Resources, Innovation & Lifestyles: Global Business Perspective

Jack De Bokx

Senior Director

Worldwide Environmental Health, Safety and Sustainability

Johnson & Johnson

UK

### Abstract

Currently our healthcare is under immense pressure. The total spend on healthcare in the US in 2010 was estimated at \$2.76 trillion and expected to rise \$3.62 trillion in 2016 (Plunket Research). According to the Centres for Medicare and Medicaid Services, this is around 17.5% of the US economy. Total spending on public healthcare in the UK in 2011 was £121.2 billion, 23% of total public spending ([ukpublicspending.co.uk](http://ukpublicspending.co.uk)). Other countries around the world are experiencing similar high numbers and growing spending on healthcare. Although there are no exact figures, data shows that an increasing percentage of healthcare cost in the developed countries is spend on 'lifestyle' diseases, such as obesity and related diabetes type 2 and various illnesses due to the use of substances such as tobacco and alcohol.

Our society, in collaboration with the health care industry phases a significant task to focus on these illnesses and reduce the burden these bring. For the healthcare industry this creates a dilemma, as the easiest solution to resolve 'lifestyle' diseases would be prevention. However, this needs effort from everyone in our western society, not just the health care industry.

However, health care industry has to play its part in moving from cure to prevention, and might even develop this as a business model. Within Johnson and Johnson one of the business units, the Human Performance Institute is doing exactly that – it provides programs and tools for organizations to lead healthier lifestyles, physically – emotionally – mentally and spiritually – do reduce the risk of stress, weight and inactivity related illness. This has a significant impact on resources, as this moves away from physical products to a service – with studies showing that the result is in many cases better – and it will increase the efficiency of the workforce, as the engagement will increase.

Obviously there are diseases which are not or only slightly related to lifestyles and for which pharmaceutical and medical device products are still necessary. For these products we have developed programs and tools to reduce raw materials and resources needed to manufacture and to use these products, working together with health care providers, such as the NHS and Kaiser Permanente and being an active member of Practice Greenhealth.

Moving from cure to prevention where possible, with innovative business models and reducing the impact of products, where these are still necessary can create a winning healthcare; more efficient, less expensive and in general better for our society!

## Procurement as Driver of Sustainable Product-Service Innovation

Cecilia Bratt

PhD student

Blekinge Institute of Technology

371 79 Karlskrona

Sweden

Göran Broman

Professor and Research Director

Blekinge Institute of Technology

371 79 Karlskrona

Sweden

Karl-Henrik Robèrt

Professor

Blekinge Institute of Technology

371 79 Karlskrona

Sweden

Sophie Hallstedt

PhD and Head of Department

Blekinge Institute of Technology

371 79 Karlskrona

Sweden

### Introduction

#### Background

Transition towards sustainability requires radical changes in the way we produce and consume. By shifting focus in the buyer-seller situation from physical artifacts to the function to be provided, new systems may evolve, often referred to as product-service systems (PSS). PSS have potential to contribute to a sustainable society while also creating business opportunities and user/buyer benefits (Baines et al. 2007; e.g., Mont 2004; Tukker et al. 2006). A PSS includes a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customers needs (Tukker and Tischner 2006). However, the market adoption of PSS brings with it significant challenges. The demand side is still hesitant to ownerless consumption and the supply side faces economic and company culture-related challenges (e.g., Baines et al. 2007; Isaksson et al. 2011; Mont 2004). The role of the procurement function in overcoming some of these challenges has not been fully explored. The procurement function is in a position of strength in the value chain and has links to both developers and end-of-life actors and thus has a significant potential to drive change.

### **Purpose**

The purpose of this study is to illuminate how the potential of procurement practices to drive sustainable PSS innovation is currently exploited and, from that understanding, to suggest some improvements of the procurement function.

### **Methods**

This paper mainly builds on three case studies (Yin 2009) at two Swedish companies and one public organization. Two of the actors are viewed as customers and one is viewed as provider. Three cases, including a shift of focus from procuring or offering of pure physical products to procuring or offering of functionality, have been studied. Information was collected through semi-structured interviews. Additional understanding was gained through discussing also other cases in the interviews and through workshops where several other organisations participated in addition to the above mentioned main case organizations. The interviewees and participants in discussions include procurers, sustainability managers, business developers and one product developer. A Framework for Strategic Sustainable Development (FSSD) (for references see Ny et al. 2006) has been used as a theoretical basis for the study.

### **Results**

#### **Case study 1 - Provider of lighting to the public and private market**

##### **What / Background**

The company is in a process of shifting from offering long-life light sources to offering a total lighting solution with an increased energy saving potential, including, e.g., light control systems, education and financial support. To be able to offer a full lighting solution, a leading supplier of products and systems for lighting control has been acquired.

##### **Why / Incentives for selling functionality**

The main incentive is expected improved competitiveness by being able to offer a combination of increased sustainability performance and decreased life cycle costs through system solutions customized to the users' needs. A market survey on trends in professional purchasing criteria, commissioned by the company, points to durability and life cycle cost as the most important criteria. Additional customer feedback indicates that environmental impact and access to lighting expertise are aspects of increasing importance. This is reflected in the company's new value proposition; to sell total lighting solutions that include long-life low-energy lamps and that utilize the full energy saving potential of such solutions. Since the cost of replacing lamps is significantly higher than the purchasing price for any lamp, the economic argument for long-life lamps combined with control systems is strong. However, within public procurement the purchasing price is still the most significant factor (weighted as 90 % of all factors).

##### **How / Who**

A dialogue meeting is normally initiated prior to any new procurement process. In this dialogue the lighting provider presents its portfolio and often suggests criteria and motives for these criteria directly to the procurer. To create conditions for competition and remained credibility at least one other provider needs to be able to meet the criteria. In these early dialogues the presence of sellers and procurers is the norm, but occasionally a business controller from the provider also takes part. During the contract period the communication takes place mainly between purchasers (which are usually not the procurers that negotiated the contract) and regional sellers.

The company has 80 % of the public market for light sources in Sweden. However, the shift towards total solutions is slow within the public sector. The company perceives this sector as not being inclined to base decisions on the full life cycle cost. Also the private sector is perceived as slow when it comes



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to adopting total lighting solutions. Only two private customers within all of Europe currently lease total lighting solution. To quote the business developer of the case study company: *the customers are not ready yet.*

The company has decided 'to become a sustainable company', which includes involving their suppliers in the sustainability work. A code of conduct has been developed that the company uses when doing inspections at their suppliers. Regarding material handling, the company today pays an external actor for handling discarded lamps. Reuse of materials is currently not considered as economically profitable, although technically possible. The company does not believe that reuse of material will become economically viable in the future either, but recognize the possibility that customers will require reuse of the material. If so, the company believes this will lead to more expensive solutions for the customer.

### **Case study 2 - County Council for health care – procurement of a multifunction machine service**

#### **What / Background**

The county council is shifting from procuring multifunction machines to procuring the functionality of that machine, including maintenance, spare parts and consumable spare parts (toner, etc). The functionality does not include electricity and paper. The shift also includes a huge reduction in the number of printers, since most personal printers will be replaced.

#### **Why / Incentives for buying functionality**

The county council expect this procurement model to be economically preferable. This expectation is based on shared experience within a network of public procurers. The shift is also expected to reduce the energy consumption caused by printing, to decrease employees' exposure to hazardous substances and to free-up time among employees for more 'core purpose' tasks.

The county council has an environmental procurement policy and objectives for the procurement function but no formulated PSS strategy to outsource parts of the organization.

#### **How / Who**

A pre-project group is formed with the aim to build acceptance for the shift within the organization by pointing to the incentives above. This process started two years ago and is still going on. When the final decision was taken, another project group was formed which currently set the tender specification including the criteria. Prior to the tendering process, a meeting with the main providers of multifunction machines was held. Officers from the procurement unit and an environmental security officer from the county council met with sellers from the providers. The purpose for the county council with this meeting was to get more general market information. No criteria or wider collaborations forms were discussed. In the contract that was later written, the county council has agreed to pay per printed paper. Furthermore, the provider will get more money per printed unit if the multifunction machines are used instead of the remaining personal printers.

The county council chose to set environmental criteria on the multifunction machines although they will not own them. The reason is that the machines will be placed on their premises and use their electricity. The environmental criteria are developed by a Swedish governmental expert body for sustainable procurement.

### **Case study 3 - Hotel – procurement a soap distribution system**

#### **What / Background**

The company is in the process of procuring a combined soap/shampoo for the hotel rooms and a dispenser with the functionality to minimize the soap/shampoo consumption as well as total waste per hotel guest while keeping guests satisfied. The solution also includes a dispenser that is easy to handle and refill. This means that the provider should be able to sell a distribution system that minimizes the soap/shampoo consumption within it.

### Why / Incentives for buying a function

The added function of minimizing soap/consumption with remained hotel guest satisfaction is driven by a combination of sustainability performance and cost reduction reasons. The procurement manager does not chose to lease a soap system since this solution are found to be more costly and due to that this solution is not possible for the eco-labelled soap/shampoo the hotel company wants to procure.

### How / Who

The procurer eventually chose a new and small supplier. The chosen partner was found to be more responsive and flexible to adapt their product to the desires of the hotel company and was therefore regarded as a partner with which the company could work over time and develop the soap/shampoo system. The new solution now being developed is regarded as innovative by the procurement manager. The product as such exists on the market, but it is being refined and adapted to the desires of the hotel company.

The company is advanced as regards sustainability performance, and has chosen to communicate this via an eco-label. They therefore also require an eco-labelled soap/shampoo. The hotel company always share their definition of sustainability with the suppliers, and a code of conduct and supplier declaration are currently being developed.

The criteria for the soap/shampoo are developed and verified by an eco-labelling organisation with no connection to the procurement process. The hotel company collects credit points within the hotel eco-labelling systems if an eco-labelled soap/shampoo is procured.

### Main findings

The main findings from the studied cases can be summarized as:

- 1 The customers in the cases studied get added value by more customized solutions and reduced costs – all driven directly by the procurement function.
- 2 Providers can find new markets by focusing more on selling functionality and adding services based on their deep product knowledge.
- 3 Society at large also gain from the solutions in studied cases, since the procured product-service solutions will lead to reduced use of resources and reduced waste per satisfied need. However, the dialogues within the studied procurement processes misses to recognize how short- and long term win-win-win (provider – customer – society) situations can be built systematically by integrated solutions. Fundamental economic relationships create provider incentives for increased consumption and contracts are not written so that both the customers and the providers would benefit economically from supporting societal transformation towards sustainability.
- 4 The studied procurement functions indicate that the procuring actors do not have clear guidelines or routines that direct the procurement processes towards the final need of the procuring organization. For example, in case 2, printing is not the fundamental need. Instead it is to communicate, which printing is not always needed for.
- 5 The relative size on the market of actors involved or invited to dialogues seems to highly affect the innovation space and thus the outcome of the procurement dialogues.
- 6 The studied procurement practices and dialogues essentially only include one actor, the first tier, and other layers or presumptive value chain collaborators are either communicated with separately or not at all. Except for minimizing of waste, end-of-life solutions are not driven by the studied procurement functions. Moreover, the direct communications with the providers are primarily only involving the seller and neither business nor product developers are directly involved in pre-procurement dialogues.
- 7 No clear and solid and shared understanding of sustainability is informing the procurement dialogues.
- 8 The most prominent barrier to integrated, innovative and sustainability-driving solutions seems to be lack of experience and knowledge, as well as clear guidelines and organizational support for how the procurement function can exploit the full sustainability potential of PSS in a strategic way.

### Recommended guidelines

Our main recommended guidelines for procurement functions to be more driving of sustainable PSS innovation include:

- 1 The real need should be identified and used as a basis for all further dialogues.
- 2 A creative dialogue should be included prior to any competitive tender situation, informed by a robust and mutual understanding of (i) the real need, (ii) the possibilities of technology and business models to satisfy this need and by a (iii) a shared understanding of sustainability and the long-term strategic business potential of sustainable innovation.
- 3 Dialogues in line with the above bullets should include a wider range of actors such as product developers, business developers, sustainability managers, sub-suppliers, end-of-life actors, transport/logistic actors, and if needed and possible professional criteria developers and professional financial advisors. This is to not miss the potential for integrated PSS solutions. These dialogues should embrace, e.g., the issues of shifted ownership, risks and opportunities and payment systems..
- 4 Contracts should be written so that they generate win-win-win situations; for providers, customers and society.
- 5 A long-term perspective needs to be considered to allow for predictability and management of risks and opportunities. This includes to understand where, in line with first bullets, the joint venture is heading and how current decisions could lay the ground for forthcoming solutions that are even more efficient as regards functionality, sustainability and economy. This also includes to avoid repercussions caused by abrupt changes of material costs, legislation, waste management, insurances, etc.
- 6 The dialogues and exchange of information should continue during the user phase for optimal management of risks and opportunities and to allow for further predictability as regards forthcoming procurement processes.
- 7 Top level support for procuring integrated product-service solutions should be expressed in the organization. Internal awareness of the procurement strategy and its objectives is important for what decisions that are taken on a daily basis.
- 8 If needed, a strategic actor is chosen to coordinate the PSS collaboration and with which the procuring organization writes the formal contract.
- 9 If criteria development at the procuring organization could coincide with the early phases of PSS development at the providers, there is great opportunity for win-win-win solutions.

A suggested procurement process is presented in figure 1.

### Concluding discussion

A shifted focus from procuring physical products to procuring the desired functionality may speed up the market introduction of system solutions. In turn, this may lead to higher performance as regards the desired functionality, lower costs for end-customers and reduced sustainability impacts per satisfied need. Procurement practices are developing towards being more driving of sustainable innovation, but the development has so far been characterized by small steps rather than by innovative and effective changes that would promote system solutions for the satisfaction of real needs (Leire 2009; Wijkman et al. 2011). This is confirmed in the case studies of this paper. At the same time, businesses exposed to increasing global competition recognize that competitiveness can be increased by adding services to the physical product based on their deep product knowledge and at the same time make the new business model harder to copy (e.g., Mont 2004). However, there are challenges with realizing PSS and especially for successful offering of functionality. One major challenge is to understand the voice of the customer more profoundly than merely obtaining the requirements (Ericson 2007) and according to Tischner and Tukker (2006) “the starting question for any sustainable PSS consideration should be which consumer/customer needs to be fulfilled and how to create as much value as possible for the customer...”. The recommended guidelines of this paper, aims at creating a room within the procurement function to answer these questions and thus drive sustainable PSS innovation. The procurement function is in a position of strength in the value chain and has links to both developers and end-of-life actors and thus has a significant potential to drive change. To speed up the transition to sustainable consumption and production, an improved procurement process, including the above mentioned guidelines, is suggested in this paper.

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The two companies and the public organization studied are advanced as regards sustainability performance. Therefore the shortcomings found, but not necessarily the strengths of the studied procurement functions, can be expected to be found in other organizations. Future work includes to more deeply explore how end-of-life activities can be driven by the procurement function so that win-win-win (provider – customer – society) solutions are recognized and realized, including the issue of ownership of the material.

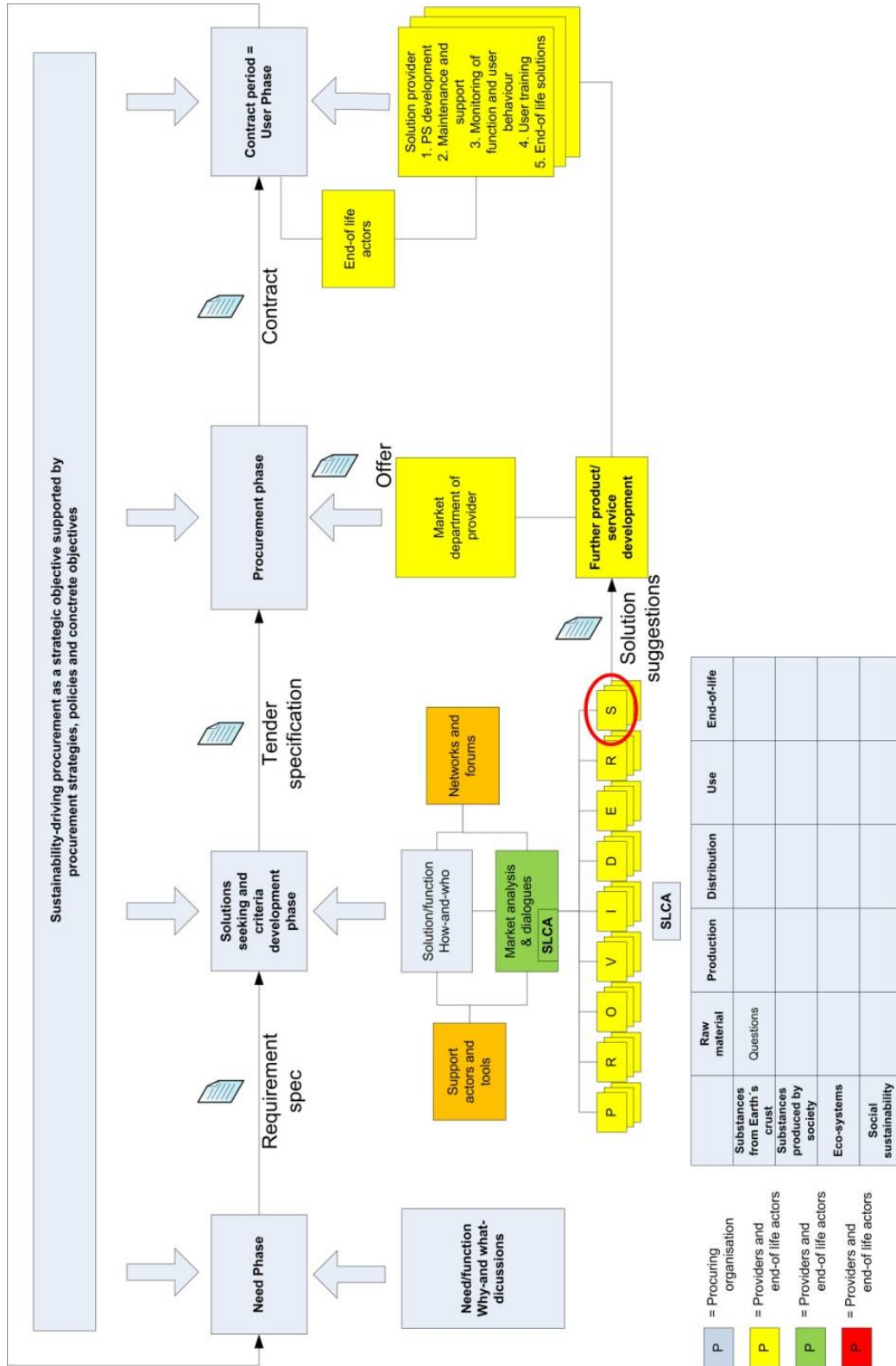


Figure 1

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# Product - Packaging Development Process: A Proposal Oriented to Sustainability

Doris Zwicker Bucci

Professor Dr.

Universidade Regional de Blumenau (FURB), Departamento de Engenharia de Produção.

Rua São Paulo 3250, Itoupava Seca- CEP 89030-00- Blumenau- SC

Brazil

Lorena Benathar Ballod Tavares

Professor Dr.

Universidade Regional de Blumenau (FURB)- Departamento de Engenharia Química

Rua São Paulo 3250, Itoupava Seca - CEP 89030-00- Blumenau- SC

Brazil

Fernando Antonio Forcellini

Professor Dr.

Universidade Federal de Santa Catarina (UFSC), Departamento de Engenharia de Produção.

Campus Universitário - Trindade - CEP: 88040-970 -Florianópolis - Santa Catarina

Brazil

## 1 Introduction

The product and packaging development process is a complex task for organizations and professionals who are involved in it. Every day it becomes more challenging, since the contemporary times require more actions for sustainable products and processes. Sustainability is recognized as an important concept by modern organizations for their survival in the competitive world (Bevilacqua et al. 2007).

Mistakes made in the design phase can affect the sustainability of products and packaging during its life cycle. Currently, the companies have focused their concerns in the environmental performance of the products using ecodesign. However, sustainable product design (SPD) is more than ecodesign, as it integrates social and ethical aspects of the product's life-cycle alongside environmental and social aspects in the creation of products and services (Charter & Tischner, 2001).

The reality has shown that most of the companies do not have their product development process (PDP) integrated to the Packaging Development Process (PkDP), but rather independent. As a result, they face competitive disadvantages, costs increases, and longer lead time. In addition, it also brings an unfavorable environmental performance for both the product and the packaging (Bucci and Forcellini, 2007). It was noticed that the models of product development in the literature and adopted by companies are not entirely appropriate, as they do not integrate the packaging and sustainability aspects from the early stages of the process.

The objective of this article is to propose a Sustainable Product-Packaging Development Process Model (SPPkDPM), integrating Product Development Process (PDP) and Packaging Development Process (PkDP) as well as the sustainable aspects since the initial phases of the process.

## 2 Methodology

The technical procedures used to collect information for the establishment of the proposed model were: the bibliographic research, field research with professionals in the industry with experience within the PDP, and PkDP and also a proposal checking by an evaluation of experts. This research can be classified as applied, qualitative, descriptive and exploratory. Figure 1 summarizes the basic steps:

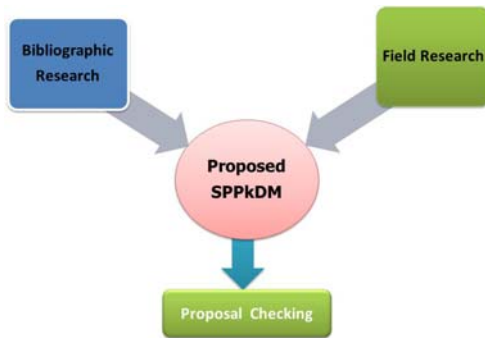


Figura 1- Basic steps of the methodology

### 2.1 Bibliographic Research

A literature review was performed in order to ascertain the state of the art on the theme of research, its problem and also to seek a theoretical study to support the requirements of the proposal. The main models of PDP and PkDP were evaluated as well as the important aspects related to packaging and the environment, ecodesign, sustainability, tools, information, techniques and best practices in PDP-PKDP.

### 2.2 Field Research

The field survey searched for information on PDP, PkDP and sustainability along with professionals of consumer goods companies with operations in Brazil ranked as large and medium-sized companies which develop products and packaging.

The procedure adopted in collecting this information consisted of a survey through interviews which used a structured questionnaire. The questionnaire was presented to 30 companies which handle consumer goods in Brazil and have experience in PDP and PkDP. The return was 20 questionnaires (67%), of which seven (35%) were applied in the form of personal interview and the remaining were by e-mail interviews. For evaluation purposes of the survey, only 19 companies were considered as a sample<sup>1</sup>, given the fact that one company does not develop the product in Brazil, and only makes applications for specific use by customers.

The questionnaire was composed of 102 questions comprising closed-form, multiple choice and open-ended questions and divided into four topics. Topic 1: company characteristics (14 questions) Topic 2: role in sustainability (13 questions) Topic 3: structure of product-packaging development process (PPkDP) in the company (22 questions) and Topic 4: how PPkDP occurs in each company (53 questions). The order of questions from topic three and four followed a logical sequence of how PDP occurs and it was prepared in order to cover all PDP-PkDP phases.

<sup>1</sup> Two cosmetic; one healthcare, one textile; four food and beverage; one household; one chemical; one food and beverage ingredient; one retail; one packaging of pulp and paper; two plastic closures; one thermoformed and injected packaging; two different materials packaging; one flexible packaging companies.

All data obtained from 19 companies were tabulated in a Microsoft Excel® spreadsheet, using a code so as not to identify the name of the company studied. Subsequently, they were organized into charts and tables and made the analysis of their content qualitatively taking as a basis Triviños (1987). A summary of the main findings of this field research will be presented in this article.

### 2.3 The proposal development

The proposal was built based upon the literature findings as well as upon the results of the field research.

### 2.4 Checking the Proposal

The conceived proposal was evaluated by experts (industry professionals and academics) in accordance with 11 criteria for evaluation of reference models, proposed by Fox (1993) cited by Vernadat (1996). Therefore, it was necessary to develop a questionnaire with 21 questions, containing 20 closed-end questions (with five choices of answer), where experts defined the intensity of response, based on the 5- point Likert scale<sup>2</sup> and one open question (general comment).

This questionnaire (together with a supporting document<sup>3</sup>) was sent by electronic mail to 23 experts. The return rate was 60.87%, corresponding to 14 responders<sup>4</sup>.

Table 1 presents the evaluated criteria and the corresponding questions for the developed questionnaire.

Table 1- Criteria evaluated and the corresponding questions

Criteria	Question
1. Scope	Q1
2. Accuracy	Q2
3. Depth	Q3,Q4,Q5,Q6,Q7,Q8, Q9
4. Competence	Q10
5. Clarity	Q11, Q12
6. Capacity	Q13
7. Generality	Q14
8. Transformation	Q15
9. Consistency	Q16
10. Extensibility	Q17
11. Completeness	Q18,Q19,Q20

<sup>2</sup> A Likert scale is a psychometric scale commonly involved in research that employs questionnaires. It is the most widely used approach to scaling responses in survey research.

<sup>3</sup> A file in MS Word® containing a descriptive text of the proposed model and another file in MS Excel ® with 10 spreadsheets. The first spreadsheet represents the model graphically and 9 spreadsheets represent each phase: consisting of model inputs, activities, tasks, tools and outputs of each stage.

<sup>4</sup> Seven mechanical engineers, one economist, one fashion designer, one product designer, two food engineers, two chemical engineers. All professionals involved had over 15 years of experience in product development and packaging, four were experts in sustainability and four had a PhD and also worked as university professors.



### 3 Results

Following are the survey results which served as support to build the model and also its subsequent evaluation by the specialists.

#### 3.1 Analysis of Bibliographical Research

The literature review showed that the various existing models of product development do not integrate the packaging. When the package is mentioned, the product has already been conceived, and does not consider the aspects of sustainability from the earliest stages of the project. The concerns with the environment are often focused on reducing or recycling material or use of biodegradable materials, etc. However, issues related to social sustainability are not even mentioned.

A gap was shown in terms of PDP and PKD models because the environmental and social issues were not considered from the early stages of the project, thus limiting the designers to reconcile environmental and sustainability requirements with other project requirements.

Most of the PKD models studied in the literature are independent models of the product. They are limited by not having adequate tools to PKDP and also because they do not integrate the product and sustainability issues. It is known that the packaging by being part of the product will affect the performance of the set if any changes are introduced either to the product or to the packaging. Thus, the performance of the set (product & packaging) should be reassessed. The Bramklev (2005) model, therefore, integrates the product and packaging, however, sustainability issues are not considered. This is a model that focuses on food and pharmaceutical industries, thus not generic. It is also limited to consumer products and to the current reality. Rozenfeld et al. (2006), reference model, therefore, constitutes a generic model with the current view of the life cycle, involving PDP best practices. Despite being very complete, it is limited to consumer products, since it considers the packaging only in the detailed design. Moreover, it does not present tools and methods for ecodesign and sustainability. The proposal of Guelere Filho et al. (2007) suggests some tools for ecodesign to Rozenfeld et al. (2006) reference model, but this proposal is also limited because it does not integrate the packaging in the early stages, and sustainability considered as a whole.

Tischner (2001) model of sustainable design, related to products, could also be, from some points of view, considered incomplete. First it does not integrate the packaging and, moreover sustainability issues focuses on environmental and economic aspects. At the same time, it does not consider the removal of the product from the market nor does it present specific tools for social sustainability.

A proposal that integrates the two processes, PDP and PKD, is suggested to be created based on the present study. This proposal should cover issues of sustainability, as well as the macro stages of pre-development, development and post-development, based on Rozenfeld et al, (2006) model. The strategies of ecodesign and sustainability tools and PKD should be incorporated in every stage of the development process and sustainability assessment should be considered before moving to the next phase (ABNT NBR ISO TR 14062 (2004)). The various models, design strategies and tools of ecodesign and sustainability studied in literature bring partial but important subsidies to be used in the new proposal.

By means of the bibliographic survey it was possible to conclude the lack of tools to assist in the integration of the product with the packaging and sustainable design. Despite the fact that large literature in terms of ecodesign tools can be found, for sustainable design of product and packaging, they are still scarce and need to be developed or enhanced to specific phases of the process and which consider sustainability.

The state of the art shows that important tools such as social LCA (Life Cycle Assessment) and LCC (Life Cycle Cost) are in early stages of development, as shown in Guidelines of Social Life Cycle Assessment of Products published by UNEP/SETAC (Andrews et al, 2009) as well as ISO 26000 (2010) norm which deals with the practice of social responsibility.

### 3.3 Analysis of Field Survey

The main results of field survey demonstrate that integrated model of PDP with PkDP is important for companies, since most of them even without an integrated model consider this integration very important. Some of them have expressed that it has already happened in practice, recognizing many benefits.

It has also been noticed that the surveyed companies are beginning to act on sustainability in product-packaging development and processes, but the used models do not integrate environmental or sustainability issues. Nevertheless, some initiatives were mentioned, with examples of products already developed that bring some environmental or social benefits.

As the environmental targets have been already part of the strategic planning of some companies, the conclusion is that sustainability goals are an important part of the strategic planning phase of the product-packaging proposal. The 4R's concept is used, the production processes are focused on cleaner production and also the eco-efficiency is already being assessed. Thus, we conclude that these tools and practices should be incorporated in specific phases of the proposal. Furthermore, companies are starting to ask their suppliers for environmental improvement of products, which should be part of the development team of sustainable product- packaging.

Companies use few tools to develop packaging and in most cases they are the same for products. It was observed that the tools of ecodesign and sustainability are not commonly known and used by most organizations. Some type of environmental labelling is already used by over half of the companies. The survey, for example, also showed that companies, even using little LCA and QFD(Quality Function Deployment) tools, recognize their importance. Thus, it is suggested that they should be part of the SPPkDM proposal.

The results of this survey were relevant to obtain subsidies needed for both in the construction of the proposed model, their phases, activities and tasks as well as to endorse the integration of PDP with PkDP.

It was also revealed that companies need to market more sustainable products due to the increasing awareness of our consumers and the urgent need for preservation of our planet. Therefore, the importance of creating an appropriate SPPkDM proposal oriented to sustainability which integrates the packaging to PDP with sustainability considerations from the earliest stages of the process.

### 3.4 The Proposal Model

The main characteristics are based on process vision and in line with the strategic business plan and sustainability of the company's product-packaging as follows:

- incorporates the process of product development to the packaging development and considerations of sustainability from the early stages of the process;
- provides an overview of the life cycle of the product and packaging as well as the entire process;
- allows adaptability;
- is represented by a graphical and descriptive visual unity;
- is decomposed into macro-phases, phases, activities and tasks;
- presents activities in logical sequence;
- presents the involved tasks for each activity, supported by the principles of Concurrent Engineering and by the guidelines of the management process design;
- shows how to perform the activities, by defining key tools (tools/methods, supporting documents, strategies, information, etc.).Sustainability tools selected for the model are written in different colours.
- shows the events that mark the end of the phases and which define the desirable results (outputs);
- assessment for passing phase through the gates;
- record of learned lessons.

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Figure 1 illustrates the proposal that is divided into three macro-phases and their division into nine phases. The macro-phases are described below:

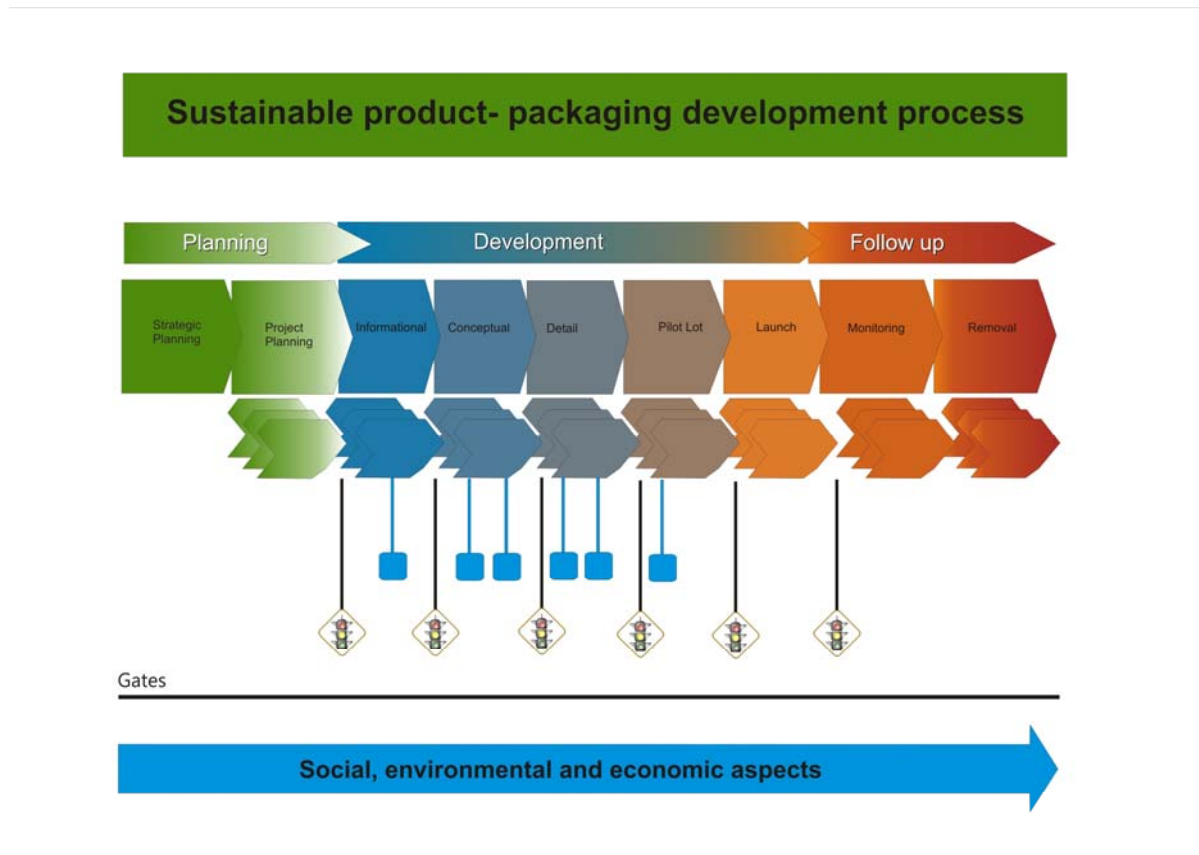


Figure 1 – Proposed Sustainable Product- Packaging Development Process for Consumer Goods

The 9 phases of the model are detailed through a written text and spreadsheets, consisting of 5 elements: inputs, activities, tasks, tools and outputs (Bucci, 2010).

- Planning - corresponds to the phases of sustainable strategic planning of products-packagings and to the project planning of products-packagings approved in strategic planning;
- Development - specific project phases covering five stages called: "informational", "conceptual", "detailed", "pilot lot" and "launch" from the sustainable product-packaging development;
- Follow up- involves the "monitoring" and "removal" phases of the product and packaging.

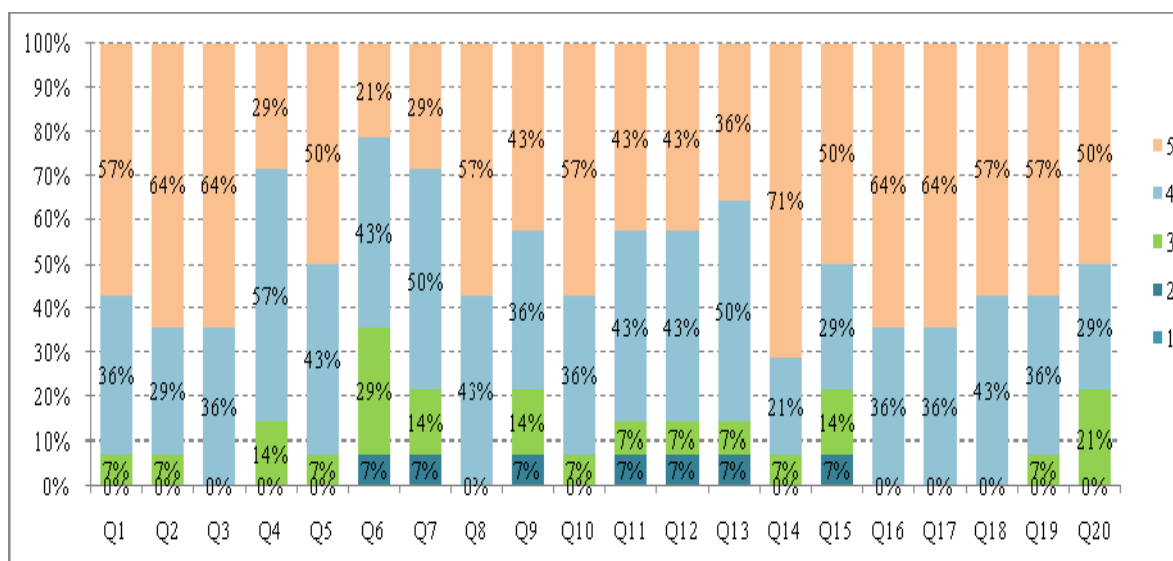
The graphical representation by arrows (pentagons) for both macrophases and phases indicate an evolving process. The representation of lozenge shaped traffic lights means reviewing each phase and the blue square represents the outputs of each phase.

### 3.5 Assessment by experts

The averages obtained per question on the evaluation by experts indicate that the proposed SPPkDP satisfactorily meets the criteria of evaluation. The general average of the views obtained was 4.37.

The comparative frequency of scores (4 and 5) with potential for improvement (up to 3) is in graph 1. As observed, 25% had 100% approval (questions 3, 8, 16, 17 and 18), 30% had 92.9% (questions 1, 2, 5, 10, 14 and 19), 20% had 85.7%, (issues 4, 11, 12 and 13) 20% received 78.6% (7 issues , 9, 15 and 20) and 5% (question 6) with 64.3%. In relation to question a greater potential for improvement of social sustainability topic on depth criteria is perceived.

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Graph 1 - Frequencies of responses based on Likert

The results corroborate that the model met the 11 assessed criteria. Importantly, the three consistency (Q16), completeness (Q10) and extensibility (Q17) criteria (the most important in order to be considered a good model), according Vernadat (1996), achieved excellent scores, as shown in the graph 01.

The comments made by the experts also confirm this, as the proposal is detailed and would have almost immediate application in the companies of consumer goods, beyond the perception of the guiding orientation.

## 4 Conclusions

The results of this study are relevant to the building of the proposal, since it guides organizations to develop more sustainable products and packaging. It can be used as a working tool, as detailed inputs for each activity and task, as well as suggesting the possible tools and needed information. It can assist in learning professionals and promote greater competitiveness in organizations. It is expected that with the regular use of the proposed model, time savings are obtained in development, besides higher quality rate, cost reduction and increased sustainability of developed products and packaging.

The evaluation of the model, by experts, showed that in addition to meeting the 11 tested criteria, the proposal can be easily implemented in consumer goods companies.

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## The 'Closed Loop' and Beyond

Martin Charter

Director

The Centre for Sustainable Design ®

University for the Creative Arts

Farnham

United Kingdom

### Greener, 'closed loop' economies

At Rio + 20 in June 2012 the global community re-affirmed 'green economy' and inclusive 'green growth' as a key focus for sustainable development policy makers. However, Europe continues to stagnate in recession with growing social unrest, whilst economic growth is now also slowing in Asia. Against this backdrop, there is increasing discussion about the theory and practicalities of the circular economy and 'cradle to cradle' thinking, alongside materials security issues, as waste increases, raw material prices continue to rise and 'critical metals' get scarcer. Moving towards wider adoption of 'closed loop' solutions will require more systemic, non-linear approaches at continental, national, regional and at company levels that will require significant shifts in thinking amongst stakeholders and structural changes to economic systems. Experience emerging from Japanese best practice on 'circular economy' includes the need to design and implement policy measures to prevent leakage of materials from national systems and the need to build materials/climate resilient supply networks.

### Policy initiatives

There is an on-going need to move towards more sustainable patterns of consumption and production and increased resource efficiency (alongside decarbonisation) is being seen a key part of moving in a positive direction. A range of European Commission (EC) and national policy initiatives in Europe aimed at driving resource efficiency have been launched in the last two years and indicators are now being developed by the EC. The relationship between resource efficiency and eco-innovation is being highlighted through the EC Eco-innovation Action Plan and both the EC Innovation Union and Resource Efficient Europe flagship initiatives. If Europe is to remain competitive it will need to find ways of stimulating both the development *and* commercialisation of resource efficient, low carbon products/services/technologies.

### Corporate developments

For companies trying to address the ever changing sustainability agenda there still is a need to think carefully and strategically about reducing the consumption of materials, energy and water throughout product/service/technology lifecycles. In today's globalised world this will mean communication and engagement with often complex networks of outsourced and/or specialist manufacturers/assemblers as well as extractive and raw materials suppliers that may be outside the scope of *normal* supply chain/network management discussion. Companies producing *technical* products will need to develop more strategic approaches that include cross-functional involvement of corporate strategy, (forward/reverse) manufacturing, (forward/reverse) logistics, marketing and design engineering/product design. This will mean re-framing business thinking. For example, 'design for remanufacturing' should increasingly be thought as a *strategic design* concept linked to new 'business modelling' rather than an operational design approach. Designing systems to retain the ownership of materials by manufacturers through service contracts with business-to-business customers may become an increasingly attractive option as raw material prices continue to fluctuate. Companies may start to think more in terms of the strategic management of materials rather than the operational and tactical acquisition of components, parts and raw materials and the procurement of recycling and waste management services. This may mean growing investment in infrastructure and technology by manufacturers to retain the ownership of products and their materials in 'closed loops'.

### **New business models**

In times of crisis there are often opportunities for innovation. There is a growing interest in developing new business models that deliver economic value whilst reducing negative and social impacts. However, as we understand more about the lifecycle of products/services/technologies there is growing recognition that influencing customer behaviour in the *use* phase may be an important element of reducing environmental impacts of, for example, 'active' products. This is leading many leading designers, innovators and entrepreneurs to start thinking more holistically of enhancing value delivered through 'production and consumption' systems rather than designing and manufacturing products per se. Re-focusing on customer needs through functional sales is likely to mean a shift in thinking towards providing combined product-service-system (PSS) solutions rather than physical products e.g. towards the need for satisfying the need for mobility rather than the production of cars. However, the psychology of consumption and ownership means that some will still want to own their washing machines and cars rather than pay for washing services or mobility services, but there are indications that mindsets are changing in some areas e.g. the growth of bike rental and car mobility schemes e.g. ZipCar in global cities.

### **Moving forward**

New information and communication (ICT) technologies are also facilitating change. At the front end both large and small companies are starting to experiment with sourcing new *green* ideas through crowd sourcing campaigns, co-developing and jamming new concepts from multiple locations and sharing unused knowledge and patents. In addition, various crowd funding competitions are being launched by both start-ups and existing firms targeted at personal investors who want to engage with environmentally/socially innovative businesses directly. Social networking technologies are driving interconnectedness, communication and information sharing with, for example, Facebook signing up its 1 billionth user in October 2012. Enabled by this, new models of sharing and collaborative consumption are emerging potentially improving the utilisation of materials and embedded energy. However, the implications for sustainability of this fast paced change are complex and will unravel over the growing decade as technology moves forward and 'Generation Y' starts to exert more influence.

## Lessons Learnt Supporting SMEs in Eco-Innovation

Martin Charter

Director

The Centre for Sustainable Design ®

University for the Creative Arts

Farnham

United Kingdom

Dr. Tim Woolman

Project Coordinator (Sustainable Innovation)

The Centre for Sustainable Design ®

University for the Creative Arts

Farnham

United Kingdom

### Background

As a business-focussed research centre at the University for the Creative Arts in Surrey, UK, The Centre for Sustainable Design ® (CfSD) has partnered in several business-support projects providing new opportunities for small business in the UK South East through eco-innovation (resource efficient and low carbon innovation). Learning points are available for wider application and are now being applied by CfSD to new business support projects applied to stimulate the 'Green Economy'.

The 'Green economy' is underpinned by SME suppliers of eco-innovative products, technologies and services, broadly composed of manufacturers, consultants, distributors, agents and other services across a range of product/market sectors. This includes a mix of a) 'start ups', b) 'businesses in transition' (e.g. existing SMEs that are incorporating eco-innovation in new and existing products, technologies and services) and c) 'growth' companies. It is important to recognise that the sector is broad based and does not just include cleantech and/or environmental technology companies.

There are no dedicated agencies in the South East of England that provide support to SME suppliers of eco-innovative products, technologies and services covering R&D, Intellectual Property Rights (IPR), commercialisation and funding. There is a need for increased 'capacity building' amongst eco-innovative SME suppliers in the South East region, if there is to be growth in Gross Value Add (GVA), sales turnover and jobs in this sector. The experience and lessons learnt from EcoMind and SUSCIN reinforce many issues highlighted in the European Commission's Eco-innovation Action Plan published by the European Commission (EC) in December 2011. Where support exists it tends to focus on cleantech or environmental technology companies and is available on a national rather than regional basis. Cleantech and environmental technology suppliers were a relatively small proportion of the SMEs that CfSD engaged with through EcoMind and SUSCIN projects and the supply base in the South East region of the UK is much broader.



### Introduction

The Centre for Sustainable Design ® (CfSD) at the University for the Creative Arts (UCA) and partners have provided eco-innovation business support to over 590 SMEs in the South-East of England between 2009 and 2012. This paper shares the findings, lessons learnt and conclusions from two European Commission (EC) funded projects, EcoMind and SUSCIN (see Appendices A and B).

Since 2009, 566 SMEs benefitted from eco-innovation business support provided by the CfSD-led Sustainable Supply Chains through Innovation (SUSCIN) project funded through the European Regional Development Fund (ERDF) and South East England Development Agency (SEEDA) - now the Department of Communities and Local Government (DCLG). In parallel, between 2009 and 2011 CfSD supported 30 SMEs in more depth through the INTERREG IVA '2 Seas' Environmental Market and Innovation Development' (EcoMind) collaborative project.

CfSD worked with EcoMind partners in the South East of England, France and the Netherlands providing business support to a range of small and medium sized enterprise (SME) suppliers of eco-technologies, products and services. This also included creating partnerships between UK, French and Dutch SMEs. EcoMind partners together held 121 events and provided one-to-one assistance for 271 businesses.

Within EcoMind, CfSD led a series of OpenGreen© innovation and eco-design workshops, product development meetings, made introductions and connections leading to both business development event attendance, for example in The Netherlands, and to partnerships being built. CfSD also prepared reports and presentations responding to SMEs specific needs and where appropriate referred to complementary business support addressing funding, IPR and procurement.

Also in South East of England, the SUSCIN project led by CfSD provided business support, events and activities aiming to build skills and innovation capacity in SMEs and social enterprises in relation to developing eco-innovative products, services and technologies through: training workshops, one-to-one business support which included 'Meet the *Green Buyer*' events, Greenthink!© and Forward Commitment procurement services. Through SUSCIN, 204 SMEs were provided with more than 12 hours of eco-innovation business support through various interventions. A series of 'Meet the *Green Buyer*' brokerage events and '*Green Dragon*' workshops were organised offering SME suppliers of eco-innovative products, technologies and services the opportunity to pitch to buyers from private and public sector. The '*Green Dragon*' sessions were designed as a follow-up to the brokerage events and led to around 15 leads for eco-innovative SME suppliers, with commercial benefit resulting from around half of those. CfSD organised 36 GreenThink!© *green* innovation workshops (rated 88% overall by participating SMEs) that led to the identification of a significant number of new product/market opportunities and novel concepts. Through SUSCIN, CfSD also held 17 events (attended by 182 SMEs) addressing eco-innovation and related topics such as green marketing, Intellectual Property Rights (IPR) and ISO14006 (the new eco-design standard).

Business support provided through both EcoMind and SUSCIN enabled SMEs to accelerate the development of eco-innovative products, technologies and services and helped SMEs better apply sustainability thinking to their business and *products*. Typically this related to:

- a) existing eco-innovative solutions: enhancing eco-business aspects, market links; improved market research and marketing material, and,
- b) new eco-innovative solutions concepts: providing external input and referrals e.g. to potential collaborators, customers (or those representing their interests) and potential funders.

The following paper provides the findings, lessons learnt and conclusions from EcoMind and SUSCIN related to the application and diffusion of eco-innovation amongst SMEs. A survey of the 'impact' of SUSCIN on SMEs is discussed and conclusions from the lessons and implications from both projects are highlighted.

### CfSD support for eco-innovation in SMEs through EcoMind and SUSCIN

#### Environmental Market and Innovation Development (EcoMind)

The Environmental Market and Innovation Development (EcoMind) was three year EC funded programme designed to support sustainable business growth, facilitate the development and market

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penetration of the new sustainable products and services and is aligned to the European Union's pledge to tackle climate change through innovation and sustainability whilst promoting business growth. The EcoMind Programme was co-funded by the EC under the Interreg IVA 2 Seas Cross Border cooperation Programme 2007-2013 (<http://www.interreg4a-2mers.eu/en/>) – further background is provided in Appendix A.

EcoMind was delivered across the South East of England, France and the Netherlands by the following partners:

In the UK: BSK-CiC, The Centre for Sustainable Design, EnviroBusiness and WSX Enterprise.

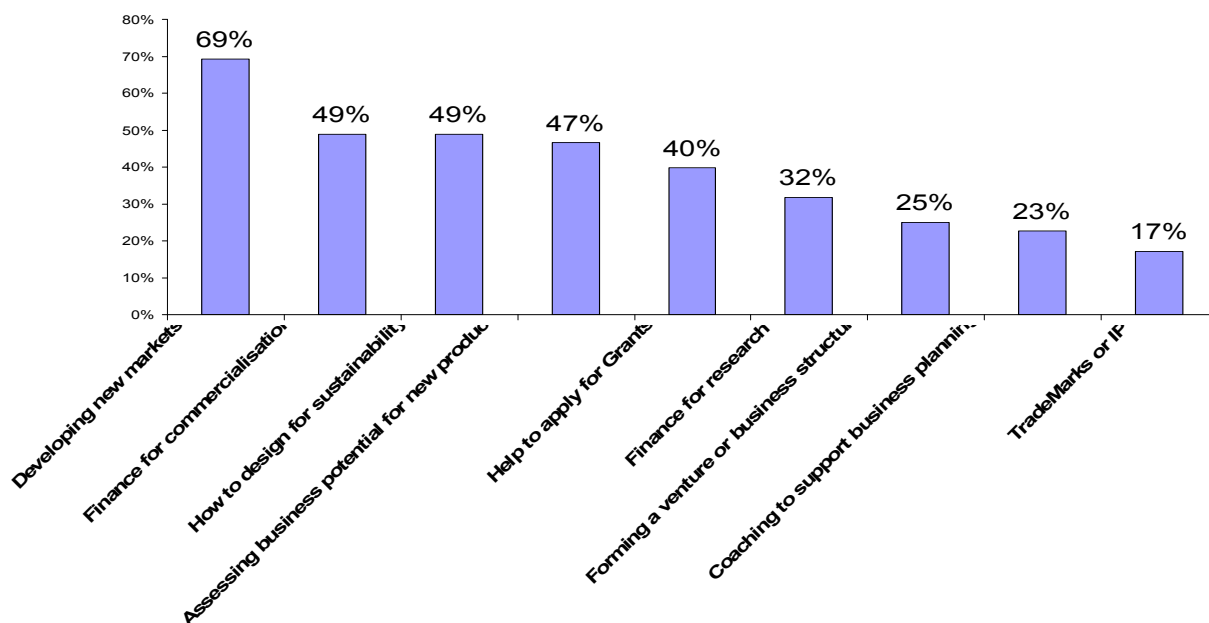
In France: CD2E and La Chambre de Commerce et D'industrie Grand Lille

In the Netherlands: Enviu and Delft Technical University

Each partner worked with a range of small and medium sized enterprises (SMEs) on eco-technologies, products and services and offered business support that included creating partnerships between UK, French and Dutch SMEs.

Over three years, EcoMind partners together held 121 events attended by 7,489 visitors, sponsored 128 individuals to attend trade fairs and workshops abroad, and provided one-to-one assistance for 271 businesses, ranging from marketing guidance and design support to assessing sources of suitable finance.

Initially SMEs interested in EcoMind support were asked to profile their needs. The results from 88 SME profiles from 2009/10 compiled by CfSD (Figure 1) showed a strong desire to develop new markets through eco-innovation (69% of respondents). 49% wanted to understand how to design for sustainability and assessing the business potential for new products was an ambition for half of the SMEs. Finance for commercialisation and research, also how to apply for grants, was also a key interest, given the financial challenges in raising finance during a period of economic downturn in the UK.



**Figure 1** – SMEs' needs for eco-innovation support (88 SMEs in South East England interested in EcoMind support).

From 2009 to 2011, CfSD provided one-to-one support for 30 SMEs responding to their needs. Commonly support was in the form of:

- Consultation on new greener business areas for development (17 SMEs)

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- Eco-product/service marketing advice and research on market aspects (14 SMEs )
- Product/service specific research e.g. eco-materials availability/supply, new or competing applications (14 SMEs )
- Signposting suitable eco-product/service development funding sources (12 SMEs )
- Networking introductions and referrals to specialist services e.g. advice on meeting sustainable procurement requirements ( 8 SMEs )
- Training on eco-design, both strategic opportunities and principles and more detailed specific learning examples, checklists etc. ( 4 SMEs )

Overall, CfSD led 10 workshops on themes ranging from remanufacturing, eco-building/retrofit and wider eco-innovation cases, 4 company-focussed workshops identifying sustainable innovation opportunities or providing eco-design training and led 2 product development meetings. CfSD made introductions to contacts for 8 SMEs leading to 16 meetings. Introductions to contacts made by CfSD led to both business development event attendance for 7 SMEs at 8 events and to 3 partnerships being built by 3 SMEs. For example, 8 UK companies were introduced to eco-innovation networking hubs (Enviu and Syntens) in the Netherlands through a 2 day EcoMind visit to Rotterdam. CfSD also prepared 20 reports and presentations and arranged promotional materials for 3 company cases. Referrals to complementary business support were typically made in the areas of funding, Intellectual Property and Sustainable Procurement.

Through providing companies with intensive business assistance, as well as a series of workshops and networking events, CfSD facilitated a number of successful improvements in eco-innovative product development processes, fostered collaborations and helped generate business for SMEs, in what was a very challenging period for many companies involved in bringing innovations to market.

### Sustainable Supply Chains through Innovation (SUSCIN)

SUSCIN was a South East England Competitiveness programme funded by ERDF and SEEDA (now DCLG) providing business support, events and activities aiming to build skills and innovation capacity in SMEs and social enterprises in relation to developing eco-innovative products, services and technologies. Support offered to SMEs in the SEEDA region (Oxfordshire, Buckinghamshire, Berkshire, Surrey, Hampshire, Isle of Wight, West/East Sussex or Kent) through the SUSCIN programme included:

**Training workshops** including sessions on Marketing your Eco-Products, Selling to the Public Sector, Understanding the Green Buyer and Research & Development.

**One to one business support** in areas such as development of sustainability policies and action plans, writing successful pre-qualification questionnaires and tenders, marketing, selling sustainability and interview techniques.

**Meet the Buyer events**, giving the opportunity to meet face-to-face with buyers and procurement managers of large public and private sector companies actively looking to source sustainable products and services.

**Greenthink!©** - A programme focussing on the development of innovative sustainable products and services, providing a mechanism for small companies to increase their competitive edge by linking resource and energy efficiency to product and service innovation.

**Forward Commitment Procurement services** aimed at stimulating the development of environmental products and services - a new and innovative approach to matching demand with supply, now being used to stimulate new sustainable solutions and better value for money to improve public services.

The 'Meet the (Green) Buyer' brokerage events were an adaption of the conventional 'Meet the Buyer' format but focused explicitly on brokering the buying and selling of eco-innovative products, services and technologies. The format was very well received.

'Green Dragons' was set up as a practical approach to complete Forward Commitments. It is a unique workshop and consultancy process designed to enable pre-vetted eco-innovative SME suppliers to pitch to buyers. Follow-up consultancy then helped to facilitate the buyer-supplier relationship with a view to converting interest into sales.

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GreenThinks!© are a unique innovation workshop designed around the individual needs of SMEs that highlighted new business opportunities and helped to develop new eco-innovative solutions. 36 workshops, customised to SMEs needs, were delivered and were very well received (rated 88% by participating SMEs). Further feedback and a video is online at [www.cfsd.org.uk/sids/greenthink/](http://www.cfsd.org.uk/sids/greenthink/)

Eco-innovation workshops were designed to provide high levels of 'added value' to SMEs with a range of presenters, panel discussion, networking and an innovation workshop session. Through SUSCIN, CfSD held 17 events for SMEs (attended by 182 SMEs) addressing eco-innovation and related topics such as green marketing, IPR and ISO14006.

Feedback from qualitative research by CfSD indicated a range of benefits were achieved through SUSCIN support. SUSCIN partners used semi-structured questionnaires to collect data on 'results' and 'impacts' of the project. Qualitative data was received from three primary research methods:

- 'Indicator' questionnaires: questionnaires were distributed to 566 SMEs and 195 responses (34%) were received including 90 comments on the benefits received.
- GreenThink questionnaires: questionnaires were distributed to 36 SME 'clients' of CfSD-UCA led GreenThink workshops with 36 responses (100%) with 36 comments on the benefits received.
- Event questionnaires: questionnaires were distributed at 17 CfSD-UCA led Events with 161 responses from 301 delegates (253 SME attendances) with 141 comments on the benefits received.

The count of the benefits cited in comments from the open-ended questions in the above questionnaires indicates the key benefits that SMEs achieved through the SUSCIN project. The top ten benefits cited by SUSCIN participants based on 267 comments overall were as follows:

- Networking/collaboration or introduction to support networks (88 comments / 33%)
- New business/product/service ideas (54 comments / 19%)
- Applying sustainability to products/services/business (26 comments / 10%)
- Further motivation (19 comments / 7%)
- Assistance with focus (18 comments / 7%)
- Proposal for developing business strategy and vision (18 comments / 7%)
- Ability to better apply 'intellectual property' (18 comments / 7%)
- Buyer engagement (15 comments / 6%)
- Improvements in marketing (14 comments / 5%)
- Planning of next steps (10 comments / 4%)

Considering the value reported of networking/collaboration or introduction to support networks, Meet the Green Buyer and SUSCIN Centres at Meet the Buyer events are recognised as important central platforms for commercial relationship building between buyers and sellers. Meet the (Green) Buyer events were also valuable for CfSD and SUSCIN partner Action Sustainability in engaging SMEs in follow-up workshop and one-to-one activities – activities which led to new business/product/service ideas and applying sustainability to products/services/business.

From the semi-structured questionnaire sent to 566 SMEs, data was collected on 'results' and 'impacts' resulting from SUSCIN. As at 1<sup>st</sup> October 2012 there were 195 responses to the 'indicator' survey which represented a response rate of 34% of the total (566 SMEs) and 60% (122 SMEs) of those that had received 12+ hours of business assistance (204 SMEs).

From the responses from SMEs, the following data on SUSCIN Outputs, Results and Impacts was compiled – Table 1.

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<b>SUSCIN Outputs, Results and Impacts</b>	<b>Cumulative value for project</b>
Business won	£2.3m
Net increase in Gross Value Added (GVA)	£0.99m
Additional employment directly related to SUSCIN (Additional employment among SMEs engaged in SUSCIN)	3.27 Full Time Equivalent (FTE) jobs (114.35 FTE jobs in 31 SMEs)
Number of businesses improving performance	18
Number of businesses increasing percentage of turnover attributable to new and improved products by 5%	17
Number of SMEs tendering for public sector contracts	50
SMEs tendering/bidding for public or private contract opportunities or tenders for in next 4-6 months	23 (11 identified indicative values totalling £9.4m)
Number of businesses within the region engaged in new collaboration with UK knowledge base	249 documented links
Number of businesses in the region developing R&D links with other businesses	53 documented SME-SME links
SMEs confirming SUSCIN helped to identify reductions in the environmental impacts of products/services/technologies	44
Buyers engaged reducing the sustainability impacts of their supply chains	340 buyer attendances from over 120 buyer organisations

**Table 1.** SUSCIN Outputs, Results and Impacts

SUSCIN supported a range of SMEs in reducing the environmental impact of *products* – highlighting the value of the project in the early stages of the innovation process. However, 12 hours of support is a short time period to help SMEs improve business performance. Key benefits from SUSCIN were seen in the early innovation stages where a) networking and b) new business/product ideas are of most value. Marketing workshops were offered, however many eco-innovative SMEs were often identified as being very *product* and not customer oriented – which meant that attendance was lower than anticipated.

Severe economic recession between 2009 and 2012 has meant many SMEs were focused on survival rather than growth. Despite this £2.3m business was won (£1.9m identified as public sector contracts, £0.4m as private sector) and the creation of 3.27 Full Time Equivalent (FTE) jobs was directly attributed to SUSCIN.

SUSCIN was successful in supporting SMEs tendering for public sector and public sector supply chain contracts especially through ‘Meet the Buyer’ and ‘Green Dragons’ activities. Despite the economic recession, a high value of public sector contracts was generated via SMEs and a number of SMEs indicated that they would be tendering for future contracts.

SUSCIN also engaged with a high number of buyers through a range of interventions.

There was a high level of interaction of SMEs with the ‘Knowledge Base’ with 249 documented links. After participating in SUSCIN, 39 SMEs are moving to a deeper level of engagement with CfSD through participation in separately organised and funded projects.

Through both the EcoMind and SUSCIN projects CfSD and partners have provided eco-innovation business support to over 590 SMEs in the South East of England between 2009 and 2012 through targeted workshops, creative Greenthink© sessions and further one-to-one support according to companies’ needs. This interaction builds on the CfSD team’s understanding of SMEs’ position in often difficult start-up and trading conditions, as well as how to enhance their capabilities in

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responding to a range of eco-innovation challenges and opportunities. The lessons learnt are summarised below.

Progress was made in SMEs' eco-product, service and technology development and better applying sustainability to their business, typically either, a) with existing eco-products/services; enhancing eco-business aspects, market links; improved market research and marketing materials, or, b) with new eco-product designs or product/service concepts; providing external input and referrals e.g. to potential collaborators, customers and potential funders.

CfSD is continuing to work with SMEs that received business assistance through EcoMind and SUSCIN as part of an EC Interreg IVA funded eco-innovation project titled FUSION (2012-2014) seeking to apply some of the lessons learnt through EcoMind and SUSCIN – 27 SMEs are engaged to date with a further 13 registering their interest.

### Lessons Learnt Supporting SMEs in Eco-Innovation

Lessons from EcoMind drawing on CfSD and broader EcoMind evaluation (Birch 2012) related to delivering suitable SME support, include:

1. **Helping SME businesses capitalise on evolving market needs is of most value:** SMEs seek market intelligence on market trends, particularly as some green market niches become more mainstream. Some SMEs need Forward Procurement to fund development prior to wider launch.
2. **Seeking external funding is a common interest and challenge:** Some specific funding is available and some is targeted at eco-innovation, but application processes are a (perceived) challenge.
3. **Product, service or technology development takes time and business support needs to be flexible in breadth and depth:** Often CfSD intervention has been at an early stage to get *green* innovation going and results take time to come to fruition, particularly in terms of commercialisation of new solutions – longer than the EcoMind target of 1-2 days business assistance per SME. Some flexibility is needed to provide lighter touch support for a larger number of SMEs and greater duration of deeper support for a smaller number of SMEs with particular needs - to build/develop solutions in more depth. A portfolio of services should be communicated early to enable SMEs to access support of the right type and depth, dependant on their interests and need.
4. **Tools to evaluate progress needs to be developed:** There needs to be a suitable process for SME-friendly product-related environmental evaluation beyond basic eco/design comparisons. Evaluation would ideally help establish the baseline performance before making changes and the specific level of environmental improvements achieved by SMEs.
5. **SMEs have common interests but want a tailored service:** Core topics (finance, marketing, market access) were often raised, though eco-entrepreneurs prefer to receive what they perceive as a customised service adapted to their motivations and time pressure.
6. **Clusters and SME-SME partnerships can be effective when established and maintained:** French partners in EcoMind worked effectively on supporting events and networking through two themed clusters; TEAM (environmental technologies applied to materials and the recovery of industrial waste and by-products) and AquaPRIS (water efficiency). "Clusters provide long-term benefit for SMEs and for the region by supporting innovative SMEs, access to funds, new jobs, and solutions to reduce environmental impacts, increased competitiveness and skills" (Birch 2012).
7. **Cross-border working needs stimulation and resources:** By working with contacts in different countries the EcoMind partners were able to gain market awareness and introductions for supported SMEs, helping them with their internationalisation. For example CfSD-supported UK companies interested in trading on the continent were able to meet and discuss the eco-innovation markets particularly with Dutch peers and experts. EcoMind subsidies enabled 124 individuals to attend events outside their country – without subsidies and facilitation many SMEs would not have travelled. Enabling networking across a cross-border partnership however did require time to promote effective understanding and suggest the most suitable SME-SME matches.

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Lessons from SUSCIN drawing on CfSD evaluation (Charter 2012) include:

1. **Product, service and technology development takes time:** As with EcoMind, it takes time for support to show results, particularly in terms of product development success being realised and measurable in the marketplace. The time to enable this was beyond the targets of SUSCIN funding, designed to reward only 12 hours business assistance per SME.
2. **Intervention early in eco-innovation is most beneficial:** Responses highlighting the benefits from SUSCIN showed particular value in the early innovation stages from support activities incorporating networking and the stimulation of new business/product ideas. The SUSCIN GreenThink!© process seemed to act as catalyst to motivate SMEs to start a more strategic and focused approach to eco-innovative product, service and technology development processes.
3. **Many eco-innovative SMEs are product rather than customer-focused:** Many eco-innovative SMEs are very 'product or technology focused' and weak in marketing/sales skills. Green marketing workshops were offered through SUSCIN, and many participating SMEs were challenged in changing from a product to a customer orientation.
4. **Business support may need to adapt to broader economic and market conditions:** When SMEs' focus is on cost reduction and business survival, there is also a challenge to raise SMEs' ambitions to respond to support partly designed to enable growth.
5. **Eco-innovation workshops which are interactive deliver most benefit:** Key SUSCIN activities that generated 'outputs', 'results' and 'impacts' were 36 GreenThink!© workshops, 5 'Green Dragons' workshops and 6 Eco-innovation events which benefitted from interaction particularly through the integrated OpenGreen© session – an open innovation ideas and development process that CfSD adapted from the GreenThink!© process.
6. **Greater SME engagement tends to enable more significant results to be achieved:** The SMEs that reported the most positive 'results' and 'impacts' from SUSCIN generally attended a broader mix of events and those increasing turnover and winning contracts, typically received higher levels of support hours.
7. **There are many and varied opportunities to achieve environmental benefits:** 20% SMEs identified finding opportunities to reduce the environmental impacts of products/services/technologies as a benefit from their interaction with the SUSCIN project.
8. **Regional focus or clustering could help business support be more effective:** A more integrated model of delivery of business assistance to SMEs focused on key cities and/or regional clusters in South East England would have provided more sustained engagement with a higher proportion of SUSCIN-supported SMEs and would have potentially built more lasting capacity in those geographical areas.
9. **Complementary forms of communication are needed to engage busy SMEs in new processes:** Experience from implementing the SUSCIN project has highlighted the need to utilise a full range of communication tools to: a) raise awareness, and b) attract SME to the project e.g. website, e-marketing, telemarketing, direct mail, press releases, videos, e-newsletters and social networking activities. Experience through SUSCIN suggests that e-marketing coupled with social networking activities followed-up by telemarketing are essential tactics to attract and engage SMEs, as many SMEs need to be reminded several times from multiple sources as to the benefits of SUSCIN activities due their busy schedules and competing priorities. GreenThinks©, OpenGreen© and 'Green Dragons' were all new and innovative workshop processes that were developed and implemented within SUSCIN. Videos were produced for all three processes to improve understanding [www.cfsd.org.uk/sids/videos](http://www.cfsd.org.uk/sids/videos).
10. **Spreading sustainable procurement skills is beneficial for buyers:** Procurers still lack the training to implement sustainable procurement. Benefitting from SUSCIN partner Action Sustainability's links to buyers and knowledge of procurement processes, six SUSCIN sustainable procurement training sessions were well attended and well received (on average 94% delegates' expectations were met).
11. **SME suppliers need to look more holistically at procurement processes and their offers.** SME suppliers benefit from advice on how to engage buyers. Even B2B suppliers need to be aware of final market and competitive drivers, to get beyond competition based mainly on price. SMEs need an awareness of the wider group and the dynamics of individuals involved in the procurement influencing and decision-making process - not just the Procurement Team. SMEs need support to help them break through the internal and process barriers in procurement in large companies. Another key lesson learnt was the need to facilitate collaboration between trades and

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SME suppliers to ensure that 'total service' packages can be offered to customers. Through SUSCIN, Action Sustainability organised workshops prior to the 'Meet the (Green) Buyer' events where SME suppliers were briefed about how 'pitch' to buyers to improve sales presentations. The 'Green Dragons' process included follow-up one-to-one support to get the right messages through to a broader set of buyer representatives. The process takes time to generate hard commercial benefits, however there were a number of successes in SUSCIN.

12. **Supplier-buyer brokerage delivers benefit and greener procurement, notably through public sector contracts, is open to SMEs:** Suppliers of eco-innovative products, services and technologies still often struggle to develop and market their products effectively. Key SUSCIN activities that addressed this and generated 'outputs', 'results' and 'impacts' were: 'Meet the (Green) Buyers' brokerage events; SUSCIN Centres in mainstream 'Meet the Buyer' events and the 'Green Dragons' process. 8 SMEs identified Business won as Public Sector (supply chain) contracts during SUSCIN (2009-2012) with a total value of £1.9m.
13. **Forward Commitment is a new and valuable concept:** Forward Commitment links eco-innovation to procurement – practised through the 'Green Dragons' workshops and follow-up one-to-one support within SUSCIN. Some of the 'Green Dragons' work related to existing products which developed commercial transactions and some related to new projects. Follow-up research indicated potential new business in the pipeline attributable to the 'Green Dragons' process.

### Next Developments

CfSD is continuing to work with a number of SMEs that received business assistance through EcoMind and SUSCIN as part of an EC Interreg IVA funded eco-innovation project called FUSION (2012-2014). Within the Interreg IVA funded eco-innovation project FUSION (2012-2014), CfSD will work more intensively with a smaller number of companies and seek to apply some of the lessons learnt through EcoMind and SUSCIN, such as those above. The CfSD target is to assist 16 SMEs in start-up, 16 in transition and 4 in the growth phase of business development.

Outside of SUSCIN, CfSD has developed a commercial version of the OpenGreen© process that it has been delivered to Taiwanese, Finish, Swedish and Spanish companies. CfSD is also actively looking to commercialise the GreenThink!© and OpenGreen© processes targeting larger companies and international business networks.

In collaboration with CfSD, Action Sustainability submitted a proposal to expand the 'Green Dragons' approach on a wider European basis. The proposal was submitted for European Commission funding through the CIP Eco-innovation programme. Both are looking to build on the lessons learnt from 'Green Dragons'.

### Conclusions

Business support provided through both EcoMind and SUSCIN enabled SMEs to accelerate the development of eco-innovative products, technologies and services and helped SMEs better apply sustainability thinking to their business and *products*, typically relating to:

- a) existing eco-innovative solutions; enhancing eco-business aspects, market links; improved market research and marketing material, and,
- b) new eco-innovative solutions concepts; providing external input and referrals e.g. to potential collaborators, customers (or those representing their interests) and potential funders.

Several of the lessons learnt from the EcoMind and SUSCIN projects are similar or related, for example the particular benefit of intervention at an early stage to get *green* innovation going and the results taking time to come to fruition, particularly in terms of commercial success being realised and measurable in the marketplace. Considering the above lessons:

- There is need for catalysts that can provide independent and objective support to eco-innovative SMEs from idea generation through R&D to commercialisation. SUSCIN also reinforced the important role of these catalysts in bringing direct and additional knowledge and experience to SMEs from a broad network of business, research, technical and funding contacts.
- Interactive intervention early in eco-innovation with a customer (rather than product) focus is most beneficial with the combination of networking and stimulation of new business/product ideas



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embodied in the SUSCIN GreenThink!© process. Feedback showed SMEs participating in GreenThinks!© commonly achieved a more strategic and focused approach to development of new eco-innovative products, services and technologies which respond to market demands and broader economic/market conditions.

- Experience of business support targeted at 1-2 days (EcoMind) or 12 hours (SUSCIN), shows this is not enough time to build a relationship with SMEs to help them access new markets, understand market dynamics and/or develop new eco-innovative products, technologies and services. Business support needs to be flexible in breadth and depth.
- Enabling responses to evolving market needs are of most value and seeking external funding or buyer engagement are common interests and challenge. Applying for funding targeted at eco-innovation, is a (perceived) challenge and achieving cash flow is not necessarily reliant on external funding. SUSCIN reinforced the need for events and activities that bring together buyers and SME suppliers of eco-innovative products, technologies and services, also the need for sustainable procurement training for buyers and (until they become more established) facilitation of new Forward Commitment processes.
- Cross-border working adds a valuable dimension to support for SMEs seeking internationalisation but needs stimulation and resources. Enabling networking across a cross-border partnership needs subsidies for travel, also time to promote effective understanding through carefully matched introductions and brokering facilitation. Given these, a number of the project beneficiaries introduced through EcoMind networking are still working together on new solutions; several established commercial relationships.
- Networks of complementary (eco-)innovation services – potentially with a regional or cluster focus - need to be renewed and sustained given the on-going need for specialist advice on eco-innovation (and related resources), business initiation & development, marketing (including market research), business formation and IP. Sustaining this support benefits from integration with complementary SME-focussed institutions, clusters and regional networks
- A range of 'innovative' workshop processes were developed during SUSCIN that have potential commercial application.
- The Eco-innovation event format was developed to 'add (more) value' to SMEs to justify time 'out of the office'. The Eco-innovation events delivered in 2012 included keynote speeches, case studies from eco-innovators, a panel discussion, a number of Pecha Kucha style presentations, networking and an OpenGreen© innovation workshop.
- 'Green Dragons' primarily focused on construction and building sectors in SUSCIN. The sector is conservative, short-termist and price-driven and therefore perhaps does not have the highest potential for eco-innovative Forward Commitment procurement. A new strategy might be target specific 'green' leadership companies directly as they increasingly have a competitive interest in identifying and accessing new eco-innovative solutions.

The Eco-innovation workshop and 'Green Dragons' Forward Commitment support processes within the SUSCIN model are potentially replicable to other regions and countries, targeting cities/larger towns and building relationships with the networks already operating locally. A more integrated model of business assistance, that could benefit from a regional or cluster focus, potentially layered to build results beyond the effects from the sum of the parts, could be:

- 1) 'Meet the (Green) Buyer' brokerage event and/or SUSCIN Centre within a mainstream 'Meet the Buyer' event located in city/regional cluster, targeting SMEs and regional buyers
- 2) Eco-innovation event located in city/regional cluster, targeting SMEs
- 3) Follow-up one-to-one activities, with additional 'added value' :
  - a) GreenThink!© workshops, targeting SMEs
  - b) 'Green Dragons' targeting SMEs and selected buyers prepared for forward procurement.

CfSD is bringing the experience, knowledge and lessons learnt from SUSCIN into existing and future projects. For example, some of these learning points are being pursued in a current business support project, FUSION. FUSION project partners are able to spend longer with each client, develop and apply shared business support tools and use webinars to reduce time out of the office.

FUSION support is open to SMEs in the UK South East through 2012-2014 – see [www.cfsd.org.uk/sids/fusion/](http://www.cfsd.org.uk/sids/fusion/)

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## Appendix A: Outline of the Environmental Market and Innovation Development (EcoMind) project

EcoMind - budget € 7,057,117, duration 48 months (02/01/2008-31/10/2011), ERDF Priority 1 (Creating an economically competitive, attractive and accessible area) Objective C (Supporting innovation, research and cooperation between universities, knowledge institutes and businesses.)

“The overall aim of EcoMind is to support SMEs seeking to develop innovative products and services in taking full advantage of the growing market for more environmentally acceptable products.

To achieve this, ECOMIND partners address the specific support needs of over 270 SMEs within the cross-border area covered by the project partners, and extend their reach to a further 600 through workshops, clinics, exhibitions and other cross-border activities. By linking up their expertise across the 2 Seas area, SMEs benefit from more development opportunities.

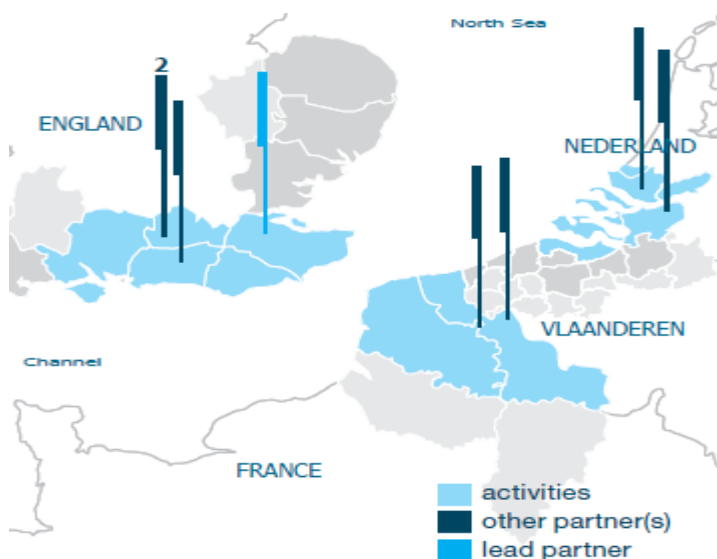


Figure 2. EcoMind project cross-border area showing partners locations - CD2E (FR), Chambre de Commerce et d'Industrie Grand Lille (FR), ENVIU – Innovators in Sustainability (NL), Enviro Business South East Ltd (UK), WSX Enterprise (UK), The Centre for Sustainable Design, UCA (UK), Technische Universiteit Delft (NL) - and the area for activities with eligible SMEs

Encouraging the public and in particular these SMEs to make full use of renewable energies is an important aspect of the project. The project will therefore profile the companies with the most environmental and economic impact, analyse the needs of eco-enterprises, define market opportunities, constitute a team of eco-innovation support specialists from across the 2 Seas area, deliver a customer support programme, and last but not least, make policy recommendations to regional and national authorities concerning future eco-innovation support priorities, the suitability of existing support provision, and how 'gaps' in provision might be addressed.” [Interreg IV A Programme Authority 2012]

Over three years, EcoMind partners together achieved the following:

- 121 events ranging from thematic/knowledge based workshops to exhibitions were organised and attendees by 7,489 visitors.

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- 128 individuals were sponsored to attend trade fairs and workshops abroad, helping them assess potential markets or find partners.
- 271 businesses benefitting from in-depth expert assistance, ranging from marketing guidance, design support, finance assessments...etc

The partners worked with many inspiring businesses such as 4 award winning companies: Kypple (France) – eco-innovation award 2010, Virus Free Air (Netherlands) – eco-innovation award 2010. , Pavegen (UK) – eco-innovation award 2011, and Aquaread (UK) - Start up Business of the Year – KEIBA 2011.

### **Appendix B: Outline of the Sustainable Supply Chains through Innovation (SUSCIN) project**

The CfSD-led Sustainable Supply Chains through Innovation (SUSCIN) project was strongly aligned with two European Regional Development Fund (ERDF) Environmental Sustainability objectives: a) market development and support for the environmental support; and b) environmental awareness.

From 2009 to 2012 566 SMEs and 119 buying organisations benefitted from the SUSCIN project. SUSCIN helped build eco-innovation capacity amongst:

- SMEs, through a) enabling networking, b) highlighting new business ideas and c) building awareness of opportunities to reduce product-related environmental impacts, and,
- buyers, through raising awareness of sustainable procurement.

SUSCIN provided notable meet-the-buyer opportunities and ‘Green Dragon’ events offering SMEs access to expanding ambitions for green procurement in the private and public sector. The SUSCIN project has provided more than 12 hours business assistance to 204 SMEs, organising four large Meet the (Green) Buyer events as well as workshops focussed on Understanding the Green Buyer, Writing a Winning Tender, Selling to the Public Sector and Winning Business in China and India. In addition four ‘Green Dragons’ sessions have led to around 15 leads generated with commercial benefit resulting from around half of those.

The key strengths of SUSCIN were: a) high level of engagement with SMEs; b) high level of interaction with buyers; c) positive feedback on Events from SMEs and buyers; d) significant innovation delivered through SUSCIN; e) success in helping SMEs tender for and win public sector contracts; and g) the positive ‘impact’ in a number of additional areas. The key weakness of SUSCIN was it was less successful in a number of ‘result’ and ‘impact’ areas due to a) economic downturn experienced during 2009-2012, b) the focus on 12 hours of business assistance which meant that it is difficult to achieve significant ‘results’ and ‘impacts’ in 1.5 days of support and c) innovation takes time to generate commercial benefits for SMEs. Nevertheless significant innovation was delivered through SUSCIN particularly from GreenThinks!®, ‘Green Dragons’ and Eco-innovation events. SUSCIN was also successful in helping SMEs tender for and win public sector contracts through project activities (Charter 2012).

# Packaging for a Sustainable Future – the Need to Cost Effectively Design for the End User and the Environment

Richard Coles

Consultant

RichColes Packaging Associates

UK

## Abstract

Packaging continues at the top of the sustainability agenda for branded fast-moving consumer goods (FMCG) companies. Market expectations, together with changing attitudes and behaviours of today's increasingly environmentally aware and health conscious consumers means that sustainability credentials of a brand and its packaging need to be addressed in a truly meaningful and well considered way. This paper will briefly outline some of the latest trends in the global food and beverage packaging market, list drivers of innovation, briefly consider the concept of "*sustainable packaging*" as defined by the Sustainable Packaging Coalition (SPC) and highlight the *Design for the Environment* (DfE) challenge. In addition to considering sustainability implications for stakeholders, it will also identify key points to consider when applying *Design for Sustainability* approaches to packaging innovation and design. Industry is encouraged to use eco-innovation, eco-design life cycle assessment (LCA) tools and "*Inclusive Design*" tools to develop more sustainably packaged products.

## 1. Introduction

The paper will:

- outline global market trends in food & beverage packaging and drivers of packaging innovation.
- define "*sustainable packaging*" and consider a number of key criteria.
- highlight the sustainability challenge for packaging innovators and designers.
- consider some implications of sustainability for stakeholders in packaging.
- identify key points to consider in packaging when *Designing for Sustainability*.

## 2. Global Market Trends in Food & Beverage Packaging

Despite the adverse global economic situation, packaging volumes continue to expand with fast-rising consumer demand and increasing affluence particularly in emerging economies. Food and beverages represent the main end-user market for the packaging industry.

*The global demand for food containers is forecast to grow by 3.9% annually to \$115 billion in 2013 (Freedonia, 2012).*

China alone is expected to account for nearly 25% of global value gains in food container demand between 2008 and 2013 (Freedonia, 2012). Although the US remains by far the largest user of food and beverage packaging, the fastest growth will occur in the Asia-Pacific region and other developing regions of the world whose economies are growing rapidly with industrialisation, urbanisation, growing population and increasing international trade. Increasing food production to supply cities whose inhabitants have diverse dietary patterns is reflected by the growth in demand for packaging. The

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increasing demand for packaging, coupled with higher sales volumes of products, is being spurred by large international retailers penetrating new and emerging markets.

According to the UN's Food and Agricultural Organization (FAO):

*“global food supply will need to increase by around 70% which is disproportionately higher than predicted population growth of approximately 30% from 7 billion people now.”*

(FAO, 2012)

The demand for pre-packaged food by the growing number of urban consumers is also being spurred by changing demographics such as the increase in single-person households. For example, the development of single portion size packs using lightweight gas barrier plastics packaging materials which can significantly extend the shelf life of food to deliver added brand value e.g. through providing convenience and improved product quality.

The growth in packaging supply may present a “cause for concern” from an environmental perspective particularly due to the implications for energy use and associated carbon emissions contributing to climate change. Also, there are other impacts associated with food production as well as consumption e.g. food and packaging waste. However, *the least (socially/economically and environmentally) sustainable packaging is that which fails to safely deliver the product to the point of consumption and prevent food waste thereby incurring environmental impact and cost often far higher than that due to the packaging itself.* Although growth in consumption is positive news from a packaging industry perspective, there is growing industry concern over pressure on supplies of certain raw materials due to increasing global demand coupled with rapidly degrading ecosystems (Packaging News, 2012).

*“We live in an age where global demand for resources is surging with prices on an upward trend and concerns about shortages mounting”*

- Gareth Stace, Head of Climate and Environment Policy, EEF –the Manufacturers' Federation, UK (Packaging News, 2012)

### 3. Drivers of Innovation in Packaging

More investment is being made in packaging innovation as a result of a variety of key drivers. For example, this may be in response to (not listed in any hierarchical order):

- increasingly diverse demands of consumers and intense brand competition;
- heightened pressure to reduce costs/improve margins in a tight global economic climate;
- a growing array of environmental, health and safety regulations;
- recent alarming rises in commodity prices and food price indices;
- the demands of a fast-expanding group of eco-conscious or eco-aware consumers;
- the corporate social responsibility (CSR) drive for more eco-efficient supply chains;
- the need to reduce dependency on fossil fuels and limit exposure to volatile oil prices;
- growing resource scarcity;
- rising cost of resources especially energy which is adversely impacted by the effects of climate change policy of governments in the EU;
- the need to reduce the carbon and water footprints of their products, including packaging, and the services used to deliver them.

#### 4. Concept of “Sustainable Packaging”

In 2005, the US-based *Sustainable Packaging Coalition*® (SPC) developed eight criteria for defining “sustainable packaging” which has been widely adopted throughout the packaging industry”. The definition provides a common vision and a framework for understanding activities directed toward improving packaging, and continues to inform the future vision of the coalition and its individual member-companies (SPC 2012).

The 8 criteria are:

1. Is beneficial, safe & healthy for individuals and communities throughout its life cycle;
2. Meets market criteria for both performance and cost;
3. Is sourced, manufactured, transported, and recycled using renewable energy;
4. Optimizes the use of renewable or recycled source materials;
5. Is manufactured using clean production technologies and best practices;
6. Is made from materials healthy throughout the life cycle;
7. Is physically designed to optimize materials and energy;
8. Is effectively recovered and utilized in biological and/or industrial closed loop cycles.

There are examples of bio-based (“made in total or significant part from renewable biologically derived materials”) plastics and paper-based packaging materials which meet or closely proximate *Datschefski’s sustainable design principles* of being *Cyclic, Solar, Safe, Efficient and Social*

(Datschefski, 2001). Their carbon footprint can be neutral or even negative based on a cradle-to-gate analysis. An example is Iggesund Paperboard ([www.iggesund.com](http://www.iggesund.com)) which is shortly to commission its new biomass energy recovery boiler at its integrated mill in Cumbria, UK (Iggesund, 2012). Iggesund plans to export electricity based on its excess renewable energy to the national grid.

However, for most biobased consumer packaging, they will be neither carbon neutral nor negative when based on a full life cycle *cradle-to-death* or *cradle-to-cradle* (McDonough & Braungart, 2002) analysis. The total packaging system (constituting 3 levels of packaging: primary, secondary and tertiary) invariably involves non-renewable finite fossil fuel resource input during (converting) distribution, production, retailing, used packaging collection and final recovery.

Sometimes, however, it may be worthwhile investing in primary packaging (contains the product) constructed from lightweight non-renewable plastics which possibly incorporate gas barrier materials. This can enable a significant improvement in functionality, such as extended optimal product quality shelf life, and/or reduced environmental impact throughout a product’s life cycle. However, the higher level of design complexity may compromise the packaging’s recyclability.

An example is the plastic tube sachet for Heinz’s ([www.heinz.co.uk](http://www.heinz.co.uk)) range of “*Squeeze and Stir*” concentrated tomato purée (70g.) instant soups which can be reconstituted using hot water (Heinz 2012). This innovation represents an alternative to the canned product. Such product developments may not only be more resource efficient and save expense but provide convenience for urban consumers who often have busy and unpredictable lifestyles.

In the case of flexible laminate and co-extruded plastics - often used in the form of pouches, sachets and bags – there can be significant savings in the amount of packaging material and energy used in manufacture as well as transport. They result in less use of non-renewable fossil fuel resources and a reduction in associated emissions.

*“Sustainability of packaging is not solely defined by its ability to be recyclable or compostable or by the material it is made from.”*

- Chris Eves, Designer, P4ACK (Rutherford 2012)

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Once used, many of these product-contaminated flexible packaging materials are often not readily recyclable unlike alternative heavier rigid packaging formats using plastics, metal or glass. Unless recycled, their likely recovery option is waste-to-energy. However, initiatives are underway within the EU and elsewhere to develop and further expand recycling infrastructure for flexible packaging in order to recover aluminum and plastics components e.g. using innovative techniques such as pyrolysis.

Thus, optimal packaging system design can serve to significantly reduce the ecological or carbon footprint and enhance resource efficiency of product supply; and recover used materials for another process thereby contributing to more sustainable production.

*“Packaging assists in the preservation of the world’s resources through the prevention of product spoilage/wastage and by protecting products until they have performed their function.”*

- World Trade Organization (WTO)

### 5. The Design for the Environment (DfE) Challenge

A key challenge for brand owners and the packaging industry in general is how to adopt sustainable principles and goals whilst addressing cost, performance and market pressures. By combining innovation and design with ecological considerations, eco-innovation and eco-design can meet sustainability goals and help enable companies to stay competitive.

In order to ensure optimal design of the packaging system, *“Design for the Environment”* (DfE) strategies are needed which include application of *eco-design* based on life cycle assessment (LCA) involving *both* the product and its packaging. This is to ensure that not only are the resource requirements and environmental impacts of packaging materials and their manufacture minimised, but also those relating to *both* the packaging and product - during production, distribution, retailing, product use by the customer and final disposal - are carefully considered i.e. the adoption of a holistic approach which balances many factors. However, the sustainability credentials of a brand and its packaging need to be continually reviewed in light of the evolving context of policy, market requirements, technological and environmental developments.

DfE strategies in relation to packaging involve, for example, developing new materials, technologies and systems which have a lower carbon footprint and consume less energy, fresh water and other raw materials. There are an increasing number of companies investing in packaging eco-design and eco-innovation strategies to generate significant cost savings both in the middle and long term, thereby improving turnover and increasing margins.

For example, within advanced economies there is exponential growth in demand for biobased packaging materials albeit from a low base. In the US, adoption of biobased products by users and manufacturers is being encouraged by the US Department of Agriculture’s (USDA, [www.usda.gov](http://www.usda.gov)) *“BioPreferred® program”* ([www.biopreferred.gov](http://www.biopreferred.gov)) launched in 2011. It also involves a biobased certification standard label. The USDA defines biobased product as *“commercial or industrial products, other than food or feed, that are composed in whole, or in significant part, of biological products or renewable agricultural materials (including plant, animal and aquatic materials), or forestry materials.”* An example of a radical bioplastics packaging innovation is Coca Cola’s 100% recyclable *PlantBottle®* made using up to 30% plant-derived material (Coca Cola, 2012). Coca Cola aims to develop a 100% biobased bottle in the near future.

In addition, there are opportunities for *eco-innovation* which can be defined as: *“innovating at the concept stage, or developing entirely new products and services (including materials and technologies) capable of performing the same function as existing ones only with significantly less impact”* (Ottman, 2011). One example is the multi-reusable and recyclable *“Bobbie”* PET bottle with replaceable cartridge ([www.waterbobbie.com/](http://www.waterbobbie.com/)) which filters municipal water as an alternative to single-use recyclable PET bottled water. Another example is Puma’s ([www.puma.com](http://www.puma.com)) *“Clever Little Bag”* as an alternative to the traditional cardboard shoebox (Pumavision, 2012).

## 6. Implications of Sustainability for Key Stakeholders and Innovators in Packaging

### (a) Government

With growing resource scarcity, it is important that Governments develop rigorous strategies to keep valuable raw materials in circulation through encouraging the development of a closed loop circular economy. At the same time, it is also important they encourage businesses to design products so they produce less waste. In addition, they need to incentivise individuals, communities and businesses to produce less waste and recycle more.

### (b) Industry

#### - Some implications for marketing

Although packaging is usually viewed by the commercial function of branded FMCG manufacturers as a major brand asset from the retail shelf to consumers' homes, the role of this asset should be viewed beyond "selling" to consider its end-of-life.

With increasing global population and urbanisation, marketers of global FMCG brands are keen to exploit new marketing opportunities in emerging economies and developing regions of the world where consumption is rising rapidly. In many markets, more affordable smaller size packs, often made using flexible plastics or laminate materials, are particularly popular. By contrast, in some countries suffering from the financial crisis and high inflation rates, there is evidence of changing consumer consumption to larger pack sizes for a wide variety of products due to their relatively lower prices.

However, there is often little or no regard by many brand owners to the environmental impact relating to anticipated high pent-up market demand and the fate of the post-consumer packaging generated. Increasing amounts of packaging waste are littering towns and countryside where waste management or disposal infrastructure is often lacking or non-existent.

This presents a particular challenge to global brands as packaging waste becomes a high profile environmental as well as social concern. For example, the sales of PET bottled beverages continue to show strong growth in markets across the world though in many cases recycling rates are often poor.

*In 2006, over 30 billion bottles of water were consumed in the United States (Campaign to End Bottled Water, 2009) – 86% of the bottles subsequently became litter or sent to landfills (Arnold and Larsen, 2006).*

Even within advanced economies insufficient attention is often paid by many brands to "*design for disassembly and recycling*" e.g. the use of shrink-sleeve labelling compromises the ability of recyclers to efficiently recycle PET bottles for beverages. For FMCG brands just to develop eco-efficiently designed packaging to meet the needs of their supply chains is insufficient. The brand owner should exercise a socially and environmentally responsible "*duty of care*" regarding the ultimate fate of its post-consumer used packaging. Also, from an environmental perspective, there are still many examples of what may be considered "*over-packaging*".

"*Green-washing*" – the false or misleading communication of environmental aspects of materials/products – remains a widespread issue. Any "green packaging" label claims should not lead to misconceptions or confusion for eco-conscious consumers. However, this is often not the case with a confusing array of claims and symbols to signify e.g. "environmentally friendly", "green", "climate friendly", "compostable" (home and/or industrial?), "biodegradable" and "biobased". Ecological benefits arising from packaging innovation should *where appropriate* be clearly communicated to users or consumers such that any claims made are relevant, specific, accurate and truthful. There should be clear on-pack labelling indicating the intended end-of-life scenario for which the packaging has been designed taking into account how realistic or probable this is given the level of access to treatment facilities for the majority of consumers.

Sustainability needs to be fully integrated into the quality of the brand, strategic thinking of the organisation and exercised at all levels – it is not an issue to be dealt with tactically by an appointed person or separate department.



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### - Some implications for the Supply Chain

There are also cost issues to consider which may be a barrier to the adoption of more environmentally compatible pack formats. For example, a well known pan-European brand manufacturer of yoghurts was “*ethically challenged*” as to whether it should continue large scale production using pots made from lower cost polystyrene. An alternative option was to use more readily recyclable and relatively lower environmental impact polypropylene though at slightly higher unit pack cost.

Another example is a UK multiple food retailer which was the first to adopt a lighter weight paper-based tray pack with a lower carbon footprint for its range of “*healthy eating*” ready meals. Although this pack was successfully adopted, the retailer later reverted to the original plastics tray when it decided to no longer accept the small price premium of this eco-innovative paper-based pack format.

However, it is a myth to consider “*sustainable packaging*” as necessarily representing an on-cost to the business. In the UK, many manufacturers miss the point with the “packaging waste levy” and see it as a tax and not as something that can be rebated. The cost argument can be challenged with examples of sustainability practice resulting in changing a cost to a revenue stream. For example, J.D. Wetherspoon’s ([www.jdwetherspoon.co.uk](http://www.jdwetherspoon.co.uk)) is the first UK pub chain to adopt glass bottle crushers at its pubs to improve space efficiency and recycling performance as well as reduce the costs, fossil fuel and transport emissions associated with collecting cullet for recycling.

Packaging made using compostable biobased materials may cost up to 2-3x that of conventional pack formats using synthetic fossil fuel plastics. However, the cost of packaging can often be quite small relative to the price of the product. The adoption of eco-innovative packaging to enhance brand image may be considered a worthwhile commercial proposition for an ecologically and socially aware company wishing to derive a *Return on Sustainability Investment* (RoSI). For example, the adoption of compostable foodservice packaging for the London Olympics 2012 well illustrates successful eco-innovation in packaging resulting from collaboration across the supply chain and beyond involving innovation networks and special interest groups (SIG).

### - Some Implications for New Product Development

Sustainability requirements should be well aligned to brand strategy and be a standard part of a packaging design brief. It should guide product innovation with eco-design or eco-innovation employed at the earliest stage of package development to ensure that the packaging system is optimised for a given product, supply chain and likely waste management scenario.

*“The most important moment in product development is when demands and specifications are decided for the product in the planning phase. The specification defines the goal for the product development process. It is a very important steering opportunity for the continuing work and for environmentally-driven demands that are to be addressed in the product development phase.”*

- in “*Ecodesign and the Ten Golden Rules*” by Luttropp, C & Lagerstedt, J. (2006)

The packaging eco-designer aims to not only balance safety, end-user, and functional product requirements with minimising resource inputs, environmental impact and costs in the supply chain; but also design packaging for a specified end-of-life recovery scenario. The latter may involve reuse, recycling, composting, anaerobic digestion or waste-to energy. To prioritise the development of minimal “*environmentally friendly*” packaging alone is insufficient to ensure the delivery of appropriately harmonised packaging solutions. The needs and values of the target market group of end users should be carefully assessed alongside ecological, cost and profitability implications.

Pack usability is becoming particularly important in countries with ageing and more affluent populations which, together with a younger more demanding consumer, have higher expectations of the brand. Brand image will be influenced by factors such as ease of pack opening or reclose facility. For example, a recent innovation is Crown Cork’s ([www.crowncork.com](http://www.crowncork.com)) *Orbit™* Closure for glass jars of jams and other preserves (Crown Cork 2012). This 2-part closure permits a significant reduction in opening torque for consumers of all ages. Increasingly, *user-centred* or *inclusive design* tools are being applied by leading brands to *enhance the brand experience* of consumers. The reader is referred to Cambridge University’s *Inclusive Design Toolkits* (Cambridge University, 2011).

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### - Some Implications for Packaging Innovators and Designers

Environmental impacts of product design and manufacture are largely market-driven. However, although market forces are beyond the control of the designer, eco-designers need to be cognizant of these forces and translate them into product characteristics in an environmentally sound way by applying *Design for the Environment* (DfE) principles (Jesweit & Hauschild, 2008).

The future will require innovators and designers with enhanced capabilities which include:

*“Many designers were held responsible for aiding retailers and FMCG clients into over-packaging and creating waste that was often not recyclable. Designers will need to become more responsible – designing ‘cradle to cradle’ packaging and packaging materials and limiting packaging to its essential role of keeping products safe or preserved.”*

Universities of Salford and Lancaster (2009) *Design 2020 Project – The Future of the UK Design Industry*

- a sound awareness of sustainability issues, new materials and technologies with enhanced sustainability credentials e.g. use of bio-based and recycled plastics;
- a depth and quality of knowledge/experience needed to develop sophisticated packaging and influence strategic brand design decisions e.g. in relation to CSR;
- a high appreciation of packaging’s role in adding meaningful brand value with due regard to meeting the needs of consumers and their wellbeing
- a sound understanding of packaging’s role in retailing, production, distribution and the environment;
- the ability to consult at all levels, create collaborative relationships and innovation networks
- an ability to apply DfE principles and inclusive design tools for the development of products and packaging with sound sustainability credentials.

## 7. Conclusion

This paper has highlighted packaging’s valuable role in contributing to a sustainable future and identified points to consider when applying *Design for Sustainability* approaches to packaging - these are summarised in the Appendix. It is argued that the packaging innovation process should be coupled to design from an end-user perspective with sustainability being an underpinning design philosophy. Packaging solutions which provide convenience and enhance the brand experience whilst minimising or reducing ecological impact and controlling costs represent an important future trend. Some implications of sustainability for stakeholders and packaging innovators have been considered and the need for a new generation of more “*sustainability attuned*” designers and innovators emphasised.

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### **Appendix - Summary of Key Points to Consider when *Designing for Sustainability* in Packaging**

- The least (socially/economically and environmentally) sustainable packaging is that which fails to safely deliver the product to the point of consumption and prevent food waste, thereby incurring environmental impact and cost often far greater than that due to the packaging itself.
- Optimal packaging system design can serve to significantly reduce the ecological or carbon footprint, enhance resource efficiency of product supply, recover used materials for another process and contribute to more sustainable production.

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- In order to ensure optimal design of the packaging system, “*Design for the Environment*” (DfE) strategies are needed and, in particular, application of *eco-design* based on life cycle assessment involving *both* the product and its packaging.
- The sustainability credentials of a brand and its packaging need to be continually reviewed in light of the evolving context of policy, market requirements, technological and environmental developments.
- Sustainability should guide product innovation with eco-design or eco-innovation employed at the earliest stage of package development to ensure that the packaging system is optimised for a given product, supply chain and likely waste management scenario.
- Ecological benefits arising from packaging innovation and design should *where appropriate* be clearly communicated to users or consumers such that any claims made are relevant, specific, accurate and truthful.
- There should be clear on-pack labelling indicating the intended end-of-life scenario for which the packaging has been designed taking into account how realistic or probable this is given the level of access to treatment facilities for the majority of consumers.
- Sustainability needs to be fully integrated into the quality of the brand, strategic thinking of the organisation and exercised at all levels – it is not an issue to be dealt with tactically by an appointed person or separate department.
- It is a myth to consider sustainable packaging as necessarily representing an on-cost to the business.
- The adoption of eco-innovative packaging to enhance brand image may be considered a worthwhile commercial proposition for an ecologically and socially aware company wishing to derive a *Return on Sustainability Investment* (RoSI).
- Successful packaging eco-innovation is often a result of collaboration across the supply chain and beyond involving networks and special interest groups (SIG).
- Sustainability requirements should be well aligned to brand strategy and be a standard part of a packaging design brief.
- To prioritise the development of minimal “*environmentally friendly*” packaging alone is insufficient to ensure the delivery of appropriately harmonised packaging solutions.
- Increasingly, inclusive design tools are being applied by leading brands to enhance the brand experience of consumers.

# The integration of Cradle-to-Cradle Principles in Building Practices in Flanders: An Assessment of the Current Situation

Wim Debacker

Researcher

VITO

Boeretang 200, 2400 Mol

Belgium

Nele D'Haese

Researcher

VITO

Boeretang 200, 2400 Mol

Belgium

Karl Vrancken

Research coordinator

VITO

Boeretang 200, 2400 Mol

Belgium

## 1. Introduction

This paper is set within the context of the building sector; a set of activities that can be held responsible for about 31% of material usage and approximately 33% of waste produced in Europe (Eurostat 2012). The built environment is also the highest energy consumer in the EU (about 40%) and a significant contributor to greenhouse gas emissions (about 36%) (European Commission 2010). Therefore, many see this sector as one of the key areas in which a transition towards sustainable development is needed.

As this transition will not happen automatically, more and more effort is being put into developing tools and concepts which can be used by policy makers and building professionals to tackle these sustainability issues. Cradle to Cradle (C2C), developed by William McDonough and Michael Braungart (2002), is one among these concepts – be it one for which attention has been increasing remarkably over the past few years. According to Potting and Kroeze (2010), this is due to the fact that C2C is an extremely powerful framework to mobilise societal and political action.

An explanation for why people find this concept so appealing must be sought in the rather positive message predominating in the C2C-philosophy. This message reads that we should become *eco-effective*, and contrasts clearly with the eco-efficiency thinking prevailing today. As Braungart, McDonough & Bollinger (2007) argue, eco-efficiency strategies only intend to maintain or increase the value of economic output while simultaneously decreasing the impact of economic activity upon ecological systems. Eco-effectiveness, on the other hand, implies rethinking our production and consumption systems and aligning them with clearly set boundaries. These boundaries involve human and ecological health, the use of renewable energy, material reutilisation and social responsibility (MBDC, 2010; C2CPII, 2012).

As an example, McDonough and Braungart refer to the continuous nutrient cycles in nature in which all outputs of one process become inputs for another. In a similar way, they state, biological and technical loops should be established in which biological and technical nutrients circulate. The latter should be understood as synthetic or mineral materials that have the potential to remain safely in a

closed-loop system of manufacture, recovery and reuse. Biological nutrients are “biodegradable materials (...) that can be used for human purposes and (...) safely returned to the environment to feed biological processes” (Braungart, McDonough & Bollinger 2007, p. 1343). Hence, the bottom-line message of C2C sounds that we can continue consuming at the same rate we are doing now, provided that the transition to an economy based on renewable energy and regenerative material loops has been made.

Although this way of thinking is increasingly gaining acceptance - see for instance the establishment of the C2C network (c2cn, 2012) - the C2C paradigm is not (yet) extensively used in the Flemish/Belgian building sector. The Flemish Public Waste Agency therefore commissioned a study on the integration of C2C features into the Flemish/Belgian building practice. This study was guided by two research questions: (1) How are building practitioners currently dealing with the C2C-principles? and (2) What are the opportunities and barriers related to the implementation of C2C?

A practical outcome of this study was a list of answers to frequently asked questions about the current and potential implementation of C2C-principles in the building practice from the point of view of architects/engineers, building principals, contractors and governmental bodies. (OVAM, 2011; Debacker et al, 2011)

## 2. C2C in the built environment: state of play in Flanders/Belgium

Partly due to the architectural background of McDonough, the built environment is one of the focus areas in the C2C-work. Another reason is the long life-expectancy of the majority of buildings, as a result of which components must be replaced or repaired on numerous occasions during the time of use. A third and final reason is the multi-layered nature of the built environment; it can be seen as a real challenge to find a supportive relationship with ecological systems and future economic growth at the level of building materials/products, buildings as well as neighbourhoods and higher functional spatial levels. McDonough and Braungart (2002) speak in this context about houses that should be designed as trees and cities as forests.

Because of this inherent complexity, no 100% C2C buildings have been built yet. An international group of architects, among one architectural office which is partly Belgian (Art&Build), have however written a manifesto ‘cradle to cradle in architecture’ (c2carchitecture, 2009) in which they engage to define milestones on the path to a real C2C built environment. In addition and complementary to this manifesto, also ‘Cradle to Cradle criteria for the built environment’ (Mulhall, Braungart 2010) has been published. Both publications provide general instructions to a wide-ranging audience for implementing C2C-principles into the building sector.

Although the C2C-paradigm is not free from critique – see for instance Reijnders (2008) who points out the fact that, contrary to what Braungart and McDonough suggest, increased emissions of wastes consisting of ‘biological nutrients’ are not ecologically irrelevant, and Schoorl in (Bijsterveld, 2008) who criticises C2C for being too much directed toward product innovation and barely addressing issues concerning spatial planning – the Flemish government allocated in the period 2010-2013 about 8 million Euros for C2C-inspired innovation projects under the name of MIP (Environmental Innovation Platform). In total, 6 projects with a clear link to the building sector received a grant. These projects contribute to the development of C2C bituminous membrane roofing, insulation materials and screed. The three other projects deal with different aspects that play when using renewable energy for warming and cooling buildings.

A similar focus on building materials/products and the use of renewable energy can be discerned among the Flemish companies (or businesses active in Flanders) that are referring directly to the C2C-concept as a source of inspiration for the development of green building products and service systems. Some good examples here are Jaga (radiators), Gyproc (plaster finishes), Wienerberger (bricks) and DS Textiles (carpets, fibres and technical nonwovens).

Yet, despite these investments in C2C-based innovation, we have not seen this translated into a greater number of C2C-certified building products. Of the approximately 80 certified building products (status when the study started in April 2010), just one product is of Belgian origin, namely Under-Cover Composite (lighting fittings) from Under-Cover bvba. This means that only this single product meets the Cradle to Cradle Design Principles set out by McDonough Braungart Design Chemistry (MBDC 2008) and was issued a C2C-certificate.

### 3. C2C building products: a synthesis

The scope of the study underlying this paper was to evaluate the practical implementation and potential environmental benefits of C2C building products. This was done through the assessment of seven products that received a C2C certificate in 2010 and one product that was under evaluation at that moment (see also Table 1). This selection was made based on (1) the availability on the Belgian market and (2) the representativeness in the building sector. All manufacturers were interviewed and available literature was critically screened.

Table 1: selection of studied building products available on the Belgian market

1.	carpet tiles
2.	zinc roof and facade covering
3.	wooden supporting elements
4.	PUR foam insulation
5.	synthetic super insulating material
6.	ceramic sewerage pipes
7.	composite light fittings
8.	leightweight masonry building block (to be assembled with mortar of glue) <sup>1</sup>

The main findings of this study can be summarized as follows:

- According to the interviewed manufacturers, the attractiveness of the C2C certification system lies in its stepwise approach through which manufacturers are stimulated to improve their products (i.e. from basic to platinum). Another plus are the simple assessment criteria. Nonetheless, for each level a complete toxicological screening is performed and the manufacturers are asked to define a road map. Both these elements were however found to stimulate innovative manufacturing.

The most significant drawbacks, on the other hand, were said to be the duration of the assessment procedure and its high price. Because this price depends on the number of components in a product, it can form a barrier for the certification of complex (building) products.

- The official online list of C2C certified products would be an effective guide for architects, engineers, building owners and promoters to select C2C materials if it wasn't so badly known. This list is also not very user friendly as less than half of the 80 certified building products listed in 2010 were (directly) available on the European market.

- Some of the requirements that correspond with the lower certification levels are hard to reconcile with the C2C principles. Only at platinum level, for example, the applicant has to prove that the various biological and/or technical nutrients incorporated in a building material can be recovered and reused. At Basic level the applicant has only to demonstrate *"the intention to optimise the product as a technical or biological nutrient product (...) when requirements for Silver or higher are not yet fulfilled"* (MBDC 2010). Given that building professionals, owners and promoters are insufficiently aware which criteria correspond to which level, the gap between the C2C principles and the low certification levels could damage the credibility of the C2C certification. So were half of the building products covered in this study to be applied or installed onsite in such a way that removal was made technically and/or financially unfeasible.

- At the time conducting this study, the C2C certificate could, according to the ISO 14020 standard (2000), not be seen as a label because the requirement of an independent, third party certification body was not fulfilled. However, at the time writing this paper this problem has been overcome. Criticisms concerning the black-box level of the certification procedures and the vague boundary

<sup>1</sup> In 2010 the lightweight masonry block was still under evaluation for C2C certification. Beginning 2012 it received a Basic C2C certificate.

between advice and certification led to the creation of the C2C Products Innovation Institute (C2CPII)<sup>2</sup>. C2CPII is an independent non-profit organisation that took over the responsibility for the certification program from MBDC and trains and certifies consultants, auditors and service providers (C2CPII, 2012).

#### 4. C2C building projects: a synthesis

In order to assess the practical implementation of C2C on building and district level, the research on which this paper draws, also covered three foreign projects, recognised as being influenced by the C2C design paradigm, and one Flemish project at district level with ambitious sustainability goals (see also Table 2). A summary of the findings of this part of the research is given below.

Table 2: selection of the studied building projects

1.	Dutch Institute for Ecology in Wageningen (NL) (building level)
2.	The head office of Bionorica in Neumarkt (DE) (building level)
3.	Park 2020 in Haarlemmermeer (NL) (district level)
4.	Tweewaters district in Leuven (B) (district level)

- Building promoters, architects and contractors saw the C2C philosophy as a conceptual framework stimulating innovation, especially when it considers the selection of materials or designing net zero-water and zero-energy buildings. C2C was however never used as a sole source of inspiration. In each studied project influences from design paradigms based on the efficient use - instead of effective use - of resources could be discerned as well, such as WWF's "One Planet Principles" (2010) and the "Living Building Challenge" (2010). The reasons mentioned to justify this, align with the opinion of experts, such as Diederer (2010) and McKay (2009), that the current demand for materials and energy cannot be matched by renewable sources alone. In addition to this, also environmental product declarations (EPDs), labels (e.g. Nature Plus) and classification systems (e.g. "NIBE's Basiswerk Milieuclassificaties Bouwproducten" (Haas 2011a; Haas 2011b; Haas 2011c; Haas 2011d; Haas & De Groot 2011e; Haas et al. 2011f) were considered useful guidance tools.

- The interviewed professionals indicated that C2C is useful for new buildings, but that it lacks guidelines to make existing buildings and infrastructure sustainable. Considering a renovation rate of 1% per year of the Belgian building stock, more than 80% of buildings in 2030 already exist today.

- C2C has its origins in product design. It therefore lacks solutions for issues that have to be dealt with when developing buildings and districts, such as the design of buildings in which components can be easily replaced, land use, accessibility and building density. The latter examples are seen as crucial design boundaries in highly built-on regions, among which Flanders (Bijsterveld 2008).

- The "waste equals food" principle led to some interesting developments in the Flemish building sector, of which the most important are an increase in the amount of leasing agreements and a higher demand for product innovations. Moreover, C2C seems to stimulate integral chain management approaches and cooperation between various economic actors aimed at combining material resources, professional knowledge and purchasing power for the purpose of recovering technical nutrients, transforming and selling them.

#### 5. Concluding remarks

Only a very limited amount of building products available on the Flemish/Belgian market are (yet) C2C certified, mainly because manufacturers find the procedure to obtain a C2C certificate long and costly. Consequentially, the C2C philosophy is used in the first place as a conceptual framework, leading to significant innovations at the building product level. In contrast with this, the C2C design paradigm was used in a more pragmatic way at building and district level. The C2C philosophy didn't seem to provide

<sup>2</sup> The headquarters of the C2CPII is stationed in San Francisco, USA. In 2012 C2CPII opened a European office in the Netherlands.



any guidance in dealing with specific spatial environmental challenges such as land use, density of infrastructure or mobility issues. It also does not take into account that most existing and new buildings are not designed to be easily deconstructed, which means that technical and biological nutrients in C2C building products cannot be recovered without technical and/or financial difficulties.

In addition to this, the research underlying this paper showed that C2C in the built environment could best be stimulated by generating and disseminating scientific knowledge. This could be done through professional educational programmes and the development of a database with objective and transparent information on environmental characteristics of building products. The main barrier perceived in this context, is the aversion to more stringent regulation in the building sector.

A final conclusion is that C2C should not be seen as a sole design and business approach, but should be seen as one way among others to make the transition to a sustainable built environment. Eco-effectiveness and eco-efficiency should (and can) be used together.

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# The Circular Economy and Responsible Leasing Within the Fashion & Textile Industry

Fatemeh Eskandarypur  
Responsible Textile Specialist  
Textiles for life,  
Founder & Owner  
Richmond  
UK

## Introduction

'Ownership is not hard anymore' – and it seems rare to find rarity these days. 'The balance between supply and demand has been altered and the value has moved elsewhere (Dykstra 2012).

The global acceleration to make exclusive more accessible and to make rare mainstream, solely based on monetary gains, has contributed towards socio-cultural imbalance, natural and human resources scarcity & tighter environmental legislation related factors.

There is a greater paradigm shift in not only regaining rarity that carries perceived values of exclusivity, transparency and trust but also the ability to appreciate and enjoy mass consumption in ways which respect our only living ecosystem and its finite natural resources through the use value of a product and the wealth presented by the stock of existing goods (UNEP 2010). However with information technology and tools allowing the tracking and tracing of materials through the supply chain<sup>1</sup> and a pervasive shift in consumer behaviour (Ellen MacArthur Foundation 2012, p11), 'the new Generation Y consumer appears to prefer access over ownership' (Dykstra 2012). This has forced the linear based economy towards a more closed loop system and a Performance Economy 'which is changing the perception of success purely based on solely monetary gains and where value and performance is based and measured on trust, quality of life, partnerships, collaborations (even with competitors) resulting in greater accumulative gains for all and experiences rather than ownership' (Stahl 2010). The result is a new and forward thinking emerging alternative economy based on responsible and innovative design where goods and services are created to have the highest possible use value for the longest possible time while consuming as few material and natural resources and energy as possible and where their cycles have no beginning and no end. (Giarini, Stahel 1989-1993).

This paper will explore and highlight the implications and applications of a performance based circular economy in terms of functional abundance rather than the traditional ownership based linear economy model in the fashion and textiles sector (both retail and contract). In addition, by taking inspiration from nature's continuous cycles (biomimetic research)<sup>2</sup>, the paper will demonstrate how eventual integrated leasing systems can optimize the use (or function) of goods and services and thus the management of existing wealth (goods, knowledge and nature) in a sector with multi layered and fragmented supply chains.

## The demise of the linear system within fashion & textiles

In 2010 an estimated £238 million worth of textiles for waste collection was sent to landfill, yet all of this could have been re-used, recycled (in the context of eventual upcycling of the product) or sent for energy recovery (WRAP 2012). A key area of short term focus is how to reduce and manage waste effectively and prolong the life span of a product under the conventional linear business model framework where currently the majority of producers/suppliers are not accountable for their products after the first use phase. This is particularly relevant in fashion and textiles where product to market

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<sup>1</sup>Track & trace tools such as Historic Futures,, product and process impact and evaluation tools such as Cradle to Cradle certification, Bluesign and footprinting tools such as Best Foot Forward

<sup>2</sup>Biomimicry Institute 3.8, <http://biomimicry.net/>

lead times have become increasingly short and their life span is determined by fashion trends rather than their technical lifetime limitations. In the USA, an estimated 13.1 million tons of textiles were generated in 2010 with a recovery rate of 2.0million tons (EPA 2012). A 2011 study by the Brussels based organization Rreuse, showed that between 2000 & 2005 the proportion of clothes collected that can be reused declined from 60% to 40% in Belgium and the Netherlands.

Typically, within the hospitality, corporate wear and healthcare sectors lead times are influenced to a lesser degree by the season or fashion trends and optimum first life expectancy is challenged to its maximum where product functionality is key. 'The Branded Workwear Report' (WRAP 2012) reveals that only 10% of no-longer-required work clothing is currently recycled or re-used. Products such as linens and towellings are rented from industrial laundries where operating margins are small and monthly rental charges are perceived as one of the highest overheads for the client. These specific products are often seen as a necessity and service rather than a product of desire. Also this sector consumes large volumes of disposables textile products where enhancing their effective biodegradability and/or responsible recycling properties are key. Yet the interrelation and role of use phase services, such as industrial laundries, small family operated launderettes, dry cleaning, clothing and textile rentals and shoe repair, with their suppliers and users (often not being the original manufacturer) are invariably fragmented and hold minimal responsibility for their products at the end of their primary use phase.

A number of progressive initiatives within the fashion and textile industry, though individual to their own organization or sector, are looking at the speed of product flow through remanufacturing, disassembly and remarketing (recycling & reuse) as a way and means to prolong the lifespan of a product after its first use phase or how to dispose of products that are short lived or for one-time usage<sup>3</sup>. Yet 'perceived "Eco-efficiency" is an outwardly admirable, even noble concept, but it is not a strategy for success over the long term, because it does not reach deep enough. Instead it works within the same system that caused the problems in the first place, merely slowing it down with moral proscriptions and punitive measures. It presents little more than an illusion of change' (McDonough, Braungart 2002).

### Designing Out Waste

In 2012 The Ellen MacArthur Foundation commissioned an executive Report, "Towards the Circular Economy"<sup>4</sup>, which exemplifies how restorative and re-balancing Circular Economy principles, applied to diverse industry sectors has not only shown an increase in improved performance but has created a long term system that is enabling responsible and creative abundance through cross-chain and cross-section collaboration as an imperative. The report highlights 4 key principles (Ellen MacArthur Foundation 2012, p7) that are evaluated in this paper in the context of opportunities with the fashion and textile sector where product usage through new types of services rendered become the key collaborative factor between business and the customer. The four principles include:

**'The Power of the Inner Circle'** – the less a product has to be changed in reuse, refurbishment and re-manufacturing and the faster it returns to use. This can be seen in the increase of Collaborative Consumption and Extended Producer Responsibility (EPR) initiatives as further exemplified in this paper.

**'The Power of Circling Longer'** - optimizing on the number of consecutive cycles of the same product, whether it be reuse, remanufacturing or recycling or duration in each cycle where products are leased or rented to diverse users such as corporate wear, occasion wear, school wear, linens and towellings within the hospitality, spa and health sectors.

**'The Power of Cascaded Use'** - diversifying reuse across the value chain, recycling or upcycling where at each stage virgin materials is eliminated or reduced in to the system such as cotton clothing where after its primary use phase it may be reused as second- hand clothing, then when no longer fit for wearing, is broken down into fibre filling for upholstery, the fibre fill is then reused for wall

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<sup>3</sup> Easytex (<http://www.easytex.tm.fr/>): biodegradeable, recyclable and disposale products for one time usage.

<sup>4</sup> A Circular Economy is an industrial system that is restorative and regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and within this, business models. (Ellen MacArthur Foundation 2012, p7).

insulations. At present no regulatory system monitors the contamination or toxic level components of a post-used fashion or textile product.

**'The Power of Pure Circles'** - where uncontaminated material streams increase collection and redistribution efficiency while maintaining quality, longevity and therefore increased material productivity. This, at present, works effectively in single component products and those designed for disassembly where each component can be reused and/or remanufactured into a new product. This has also been successfully implemented to fashion and textile products with single man-made fibre component such as polyester where the product can be disassembled and remanufactured into a similar or superior quality product<sup>5</sup>. Another example is the EcoBase® carpet tile backing by Desso.

### **Towards responsible leasing within fashion and textiles:**

#### **Extended Producer Responsibility (EPR) and 'take back' initiatives and guidelines.**

The first steps towards implementing and applying Circular Economy principles can be seen through an industry endeavouring to respond to a savvy consumer who is saturated with choice and who prefers to own less material stuff. A consumer who realises that collaborative consumption and Extended Producer Responsibility (EPR) facilitated through open-source information can bring greater returns both in monetary value as well as maintaining and nurturing the values of trust and loyalty.

An example is Patagonia<sup>6</sup>, who has been taking back clothing for over 7 years via mail or in store resulting in a saving of approximately 45 million tons of used clothing from ending up in landfills. A pioneer in the concept of EPR, they have integrated user collaboration in their supply chain, through their Common Thread Recycling programme, offering mending services and more recently through collaboration with eBay, have created a marketplace for sellers and customers to buy and sell their unwanted Patagonia products.

Recent examples of "Take back" initiatives are Puma ('Take Me Back') & Footlocker (initiatives set up by I:CO) and the M&S collaboration with Oxfam called 'Schwopping' where reward and loyalty cards schemes as well as celebrity endorsements are used to engage and retain their customers.

Also on-line exchange portals such as ebay.com, Amazon.com, Preloved.co.uk and Thredup.com have become increasingly popular across all age groups and social sectors.

In the hospitality and contract sectors there is greater potential to monitor, measure and control a product life cycle and engage their supply chain to effectively adopt and implement Cradle To Cradle and Circular Economy principles. Domestic and industrial laundries have through default and necessity, become more sustainable,<sup>7</sup> yet remain insular in approach. This is where the durable and technical service and function of a product or product system can lead to a different usage of consumables<sup>8</sup> such as a washing machine and its wash activating components<sup>9</sup>. Washing machines

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<sup>5</sup> Teijin EcoCircle (<http://www.teijin.co.jp/english/product/poly/specifics/eco-circle.html>): - polyester recycling system collaborating with Patagonia;

Backhausen Interior Textiles (Returnity fabric) collaborating with Dutch Spirit.

<sup>6</sup> <http://www.patagonia.com/us/common-threads/reuse>

<sup>7</sup> Rising water costs and more efficient energy and water management systems have proven to bring great cost savings for industrial laundries especially over the past 10 years.

<sup>8</sup> A significant part of a washing machine's total environmental impact, for example, arises from the discharge of soiled water and dissipation of detergent (Ellen MacArthur Foundation 2012).

Xeros, the brand name for a patented polymer based cleaning that creates step change advantage in the cost and environmental impact of aqueous wash cleaning. Its overall footprint is reduced by 40% if reduction in tumble drying is included (source: URS Corp. study commissioned by Xeros) due to less electricity and detergent usage than conventional systems. This calculation also includes the environmental cost of the Xeros nylon beads which will be recycled, never just thrown away.

<sup>9</sup> Waters interaction with the textile product itself – its composition, structure, previous treatments, soiling intensity; the chemicals – their concentration and diluting properties with water; steam generation – its purity, impact on the atmosphere, steam recapture and recycling; machinery & piping's – water can contain or generate corroding qualities when mixed frequently with chemicals.

are generally standardised in terms of size and carry similar components yet their longevity can vary. Also energy efficiency enhancing features are not dependent on structural changes and can often be enhanced with software electronics and sensor systems. This therefore creates a great opportunity for both manufacturer and user to benefit from a 'leasing agreement offering high end washing machines as a usage or performance based model enabling average users to profit from low per cycle costs of high end machines within a shorter period of time'. (Ellen MacArthur Foundation 2012, p47). The potential is even greater once collaboration between textile manufacturers and washing machine manufacturers strengthens and widens.

In 2006 France became the first country in the EU to introduce a nation wide producer responsibility taxing scheme where social enterprises have access to collected textile materials. However, there are also a number of new case studies (mainly in Western Europe) of cooperation between social reuse actors, private waste management companies and municipalities. Various initiatives on formalising similar type activities are now gathering significant attention in Central and Eastern Europe (Waste Management World, 2011).

Through open access and information sharing initiatives (the Eco Index, Nike Apparel Environmental Design Tool and the newly formed Higg Index)<sup>10</sup>, the fashion and textile industry is gradually being offered accessible guidance and tools to show how integrated chain management and closed loop systems depend on societal, supply chain and actor level (economic, legal & tax structures) involvement as opposed to purely company level. Their success depends on integrating private as well as industrial customers into their chain of activities. (Morana, Seuring 2011). 'Diverse systems', one of 5 key biomimetic principles on which the Circular Economy is based, 'which has many connections and scales are proven to be more resilient in the face of external shocks, than systems built just for efficiency (also applies to economies and communities)'. (Ellen MacArthur Foundation 2012, p23-24).

Large global corporations and organizations such as M&S, Walmart, Tesco, Ikea, Nike have all taken initial steps towards collaborative production through procurement initiatives set up to directly buy from farmers through schemes such as the 'Better Cotton Initiative' and assessing the ecological footprint of their decisions as well as that of their supplier. The progress towards collaborative consumption, EPR and open access information can potentially pave the way towards implementing closed loop responsible leasing systems where a shift in the psychology of ownership at all levels of the supply chain occurs. Therefore it is essential, as identified in the founding principles of the Circular Economy, to ensure waste is treated as food' (biological or technical), that energy comes from renewable sources (converting non recyclable waste materials into useable heat, electricity or fuel), enabling diverse systems where price must tell the truth and to think in terms of system processes and how one action or decision can impact another and as a whole (Ellen MacArthur Foundation 2012, p23-24).

Individuality, however, as often expressed through fashion and textiles, is not lost but gained and the supportive Circular Economy system enhances user responsibility through shared ownership, generating greater creativity and enabling fashion and textiles to be more accessible and on trend.

### **Where product becomes a service**

Allan Dykstra sees this as a new form of competitive advantage and notes that people are no longer shopping to 'own' things in the traditional sense. Instead, it is more what the product does for them and the message it communicates. (Dykstra 2012). A study in the paper by De Brito investigates methodologies within the fashion and textile industry and identifies that leasing versus selling can, under responsible supply chain management programmes and policies, have a positive economic, environmental and social impact and can eventually alleviate resource scarcity.

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<sup>10</sup> A benchmarking methodology for brand, product and facility levels of both small and large organisations enabling companies evaluate material types, products, facilities and processes based on a range of environmental and product design choices: Sustainable Apparel Coalition: <http://www.apparelcoalition.org/higgindex>

### The 'user' perspective

User centered surveys to date have shown that leasing or long-term renting and the optimization of the garment use time within the fashion industry does not initially appeal to respondents. "Innovations with a more radical approach (such as leasing) do not generally come from user-centered approaches meaning that users are tied to existing solutions and socio-cultural regimes" (Verganti 2009). User-centred surveys tend to verge towards the more familiar questions being the more popular. (Ninimäki, Hassi 2011). Yet through a circular approach, the customer/user becomes a partner and does not only depend on emotional attachment prolonging product replacement but encourages responsible flow creation by enabling their own active involvement whilst creating a sense of accomplishment and deepening awareness as well as the benefits of lower costs, greater flexibility towards customization and secondary benefits such as added functional benefits.

### The supplier/manufacturer and retailer perspective

Companies such as the Dutch based, Dutch Spirit<sup>11</sup> (corporate wear & retail clothing) and their use of Returnity fabrics<sup>12</sup>, InterfaceFlor & Desso<sup>13</sup> (contract & retail carpet manufacturers with cradle to cradle certification) and Xeros<sup>14</sup> (one-stop solutions for clothing and textiles washing and aftercare) have applied Circular Economy principles with the key goal of introducing leasing systems and services for their products. Each company has designed a clearly defined angle based on the principles and concept of the Circular Economy rather than a specific product whereby perceived barriers of leasing specifically linked to apparel and textiles such as performance, handle and hygiene have been addressed. Their pioneering approach may also see a shift in psychological barriers of 'ownership-desire'. The concept is still in early stages of application and where a period of use and take-back needs to occur in order to evaluate its benefits. Desso is already seeing the benefits and have extended their initiative to also accept used / unwanted carpets from other sources. Dutch Spirit applies a contract whereby the user or retailer places a deposit at point of purchase and they impose a penalty if the product is not returned for reuse. Dutch Spirit emphasizes that a partnership or collaboration means equal profits for all its strategic partners – in ways where trust and fairness brings greater returns for all'.

### Advanced and accurate waste material sorting and the chemical reengineering of them can create and develop a greater collaborative role with the concept and design forming stage of a textile product

The lucrative benefits and advantages of disassembling and remanufacturing of products both at the end of their useful life as well as desired life (although still in good condition for use) has brought new collaborative and creative synergies between post consumption chain players (waste management, recycling companies and also chemical companies) with material producers and the concept and design forming stage of a textile product. This can be seen in the infrastructure of waste management and recycling organisations such as ECOLOG Recycling Network GmbH, Textiles4textiles (T4T) and Re:newcell where materials are fed back to the concept forming stage of a product design process offering increasing availability of non virgin, biogenic and toxic free raw materials that enable circular economy business frameworks within the fashion and textiles supply chain, including the customer/user. Waste management companies are becoming remanufacturing companies and in turn material producers are becoming material managers such as Dupont, Teijin and Unilever.

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<sup>11</sup><http://www.dutchspirit.com/uitgelicht/returnity>

<sup>12</sup><http://www.returnity.at>

<sup>13</sup><http://www.desso.com>, <http://www.interface.com>

<sup>14</sup><http://www.xeros.com>

### Redefining 'Value'

Through customer involvement as co-creator, an emotional value is formed through deeper user satisfaction and where trust and transparency have become one of the key tools towards differentiation (Monet 2002). "Trust", has therefore "become the new social currency – as powerful as our credit rating" (Botsman, Rogers 2010). Particular design strategies to engage and gain the trust of the consumer where use value, emotional value, cultural value, social value, environmental value and future orientated value all become nuances whereby a consumer purchase, use, recycling and disposing behaviours are designed and structured to have a positive effect (Ninimaki, Hassi 2011).

Circular Economy principles also reinstates trust through the supply chain, a value often sacrificed within the fashion and textile sector for secrecy that has erroneously been applied as a key driver for creative competition.

### Responsible leasing versus the psychology of ownership

The Psychology of Ownership is shifting. In the same way it has become fashionable and acceptable by all sectors of society, including the middle-upper class, to purchase already used clothing and textiles, it may soon be the norm to lease out, not only occasion wear or corporate wear but also products such as underwear, t-shirts, towels and bedlinen. From preliminary field surveys and informal discussions, these afore mentioned types of items will be disposed of (occasionally after a second life use as rags or cleaning cloths) with normal landfill waste, and seldom taken to clothing recycling banks.

The circular economy is therefore not only enabling resource efficiency but also initiating a shift in socio-cultural perceptions and differences by creating positive change to balance human necessities as well as desires. Our level of user responsibility as a collective can therefore be enhanced through shared ownership and alleviate the need for extensive knowledge overload on products and packaging.

Responsible leasing of fashion and textiles can ultimately be aligned with Slow Design principles, enhance creativity, eliminate 'throwawayism'<sup>15</sup> and enable clothing, textiles and shoes to be more accessible in terms of responsible fashion, function (including after life) and design.

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<sup>15</sup> Design against Throwawayism, <http://www.carbonislife.com>



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## Sustainability Self-Assessment and Business Model Design

César Levy França

PhD Student

Blekinge Institute of Technology

371 79 Karlskrona

Sweden

Göran Broman

Professor

Blekinge Institute of Technology

371 79 Karlskrona

Sweden

Karl Henrik Robèrt

Professor

Blekinge Institute of Technology

371 79 Karlskrona

Sweden

Louise Trygg

Professor

Linköping University

Linköping

Sweden

### Introduction

The business case of sustainability has been argued for by many authors (Willard, 2005; McNall et al., 2011). There is a large degree of consensus regarding the potential business impact of sustainability. However, most companies either are not acting or are falling short on execution. (MIT Sloan, 2009). Relatively few companies consider innovation for sustainability substantially rewarding. Suggested solution for this includes better access to frameworks for understanding sustainability and value creation and the business cases thereof (MIT Sloan, 2009). Furthermore, it is well-known that support for generation and selection of ideas and for formulating goals and strategies is especially essential to have during the early phases of the innovation process (Roozenburg & Eekels, 1995).

The usual absence of an operational definition of sustainability is still a major barrier to corporate strategic sustainable development (Holmberg & Robèrt, 2000). A sustainability definition that can guide assessment of the current situation and stimulate generation of ideas for upstream solutions and strategic guidelines that can aid prioritization of early smart actions are among the most promising leverage points. A framework including those features is being developed in an international consensus process since twenty years (see, e.g., Robèrt et al., 2012). Among other things, this Framework for Strategic Sustainable Development FSSD, clarifies the self-interest in sustainability work and thus supports more widespread and proactive sustainable innovation.

In this study, the FSSD is used as the main basis for a new tool to be used in early phases of the innovation process for self-assessment of an organization's current maturity and performance from an overall strategic sustainability point of view and for stimulating generation of ideas for business models

design. We present a prototype version of such a tool and results from initial tests of this tool performed in four organizations. We study in particular whether the outlined tool is perceived by the organizations to be: (i) easy to comprehend, (ii) relevant, (iii) capable of differentiating the organizations in a comprehensive way, (iv) helpful for discovering insufficiencies that the organizations are not already aware of and (v) helpful for generation and selection of ideas for upstream solutions, business model innovation and for formulation of goals, and strategies.

### Methods

The development of the sustainability self-assessment tool and related methodological process was guided by a Framework for Strategic Sustainable Development FSSD and its operational process backcasting from sustainability principles.

The Framework for Strategic Sustainable Development (FSSD), used as a foundation for this study and tool development, provides a generic support for backcasting planning in any field at any scale by applying generic sustainability principles as boundary conditions. The FSSD comprises five levels:

1. The system level – prompts a description of a topic with its nested subsystems in society in the biosphere,
2. The success level – prompts a description of success for the topic (e.g., success for a company in a future sustainable society), informed by basic sustainability principles,
3. The strategic level – includes guidelines for stepwise approaches towards compliance with the defined success,
4. The action level – prompts for concrete actions aligned with the strategic guidelines and put into a plan for compliance with the defined success, and
5. The tools level – links to concepts, methods and tools to support and monitor the transition between current situation and the defined success.

Backcasting implies that a successful outcome is imagined in the future, followed by the question: “what do we need to do today to reach that successful outcome?” The basic sustainability principles (level 2) have been derived from understanding first-order mechanisms through which society currently causes destruction of the socio-ecological system, and reads:

In a sustainable society, nature is not subject to systematically increasing...

1. ...concentrations of substances extracted from the Earth’s crust (e.g. fossil carbon and metals);
2. ...concentrations of substances produced by society (e.g. CFC’s and NOX);
3. ...degradation by physical means (e.g. deforestation and overfishing)  
and in that society
4. ...people are not subject to conditions that systematically undermine their capacity to meet their needs (e.g. through abuse of economic and political power).

The overarching guideline for organizations to support society’s compliance with these principles is to integrate them with the objectives of the organization, i.e., applying the sustainability principles as boundary conditions for redesign of visions and objectives, and then backcast from that integrated overarching goal. The FSSD implies a step-wise approach, ensuring that early steps are designed to serve as (i) flexible platforms for forthcoming steps that, taken together, are likely to bring the organization to the defined success by striking a good balance between (ii) direction and advancement speed with respect to the defined success and (iii) return on investment to sustain the transition process. A more comprehensive description of the FSSD is given by, e.g., Robèrt et al. (2012).

Other approaches, concepts, methods and tools that have been considered and used as a background for this study and tool development include, life cycle management (Ny et al., 2006), eco-design (McAlbone et al., 2008), sustainable product development (Hallstedt, et al., 2008), green procurement (Bratt, C., 2011; LEAP-GPP, 2006; Williams et al., 2007; Procura+ ICLEI, 2007),

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sustainability driven goals, targets and indicators (França et al., 2009), business models (Osterwalder & Pigneur, 2010; Casadesus-Massanell & Ricard, 2010; Margreta, 2002; Teece 2009).

Testing and refinement of the proposed tool were supported by workshops and interviews with professionals from the following case study companies (Table 1.):

**Table 1: Case studies**

Organization	Activities	Persons involved	Time
Cascades Djupafors AB (Packaging industry)	2 workshops 1 interview/ assessment	Purchasing Managers Sustainability Experts – BTH	March / April 2010
Tetra Pak Technical Service AB (Food process and packaging industry)	2 workshops 1 interview/ assessment	Manager of Purchasing Department for Base Materials Sustainability Experts – BTH	March / April 2010
Scandic Hotels AB (Hotel chain)	2 workshops 1 interview/ assessment	Manager of Sustainable Business Sustainability Experts – BTH	March / April 2010
Affärsverken AB (Energy utility)	2 workshops 1 interview/ assessment	Managers, Project Directors from the company and municipality. Sustainability Experts – BTH	October / November 2010
Volvo Construction Equipment AB (Heavy machinery industry)	1 workshop	Managers, researchers and project directors Experts - BTH	October 2010

## Results

The proposed tool consists of three main parts:

### 1. The Sustainability Self-Assessment Matrix

A self-assessment matrix (Tables 3-7) displays the five levels of the FSSD with an added set of statements and in relation to each of those four maturity degrees (MD). The MDs represent the organization's maturity in addressing sustainability issues in a strategic way.

### 2. Sustainability Profile Visualization

A visual representation of the organization's sustainability profile is included in the tool to give a compact and easily accessible overview. As seen in Table 6 the case studies show a wide variety of sustainability profiles. For confidentiality reasons we do not indicate in this paper which profile that belongs to which organization.

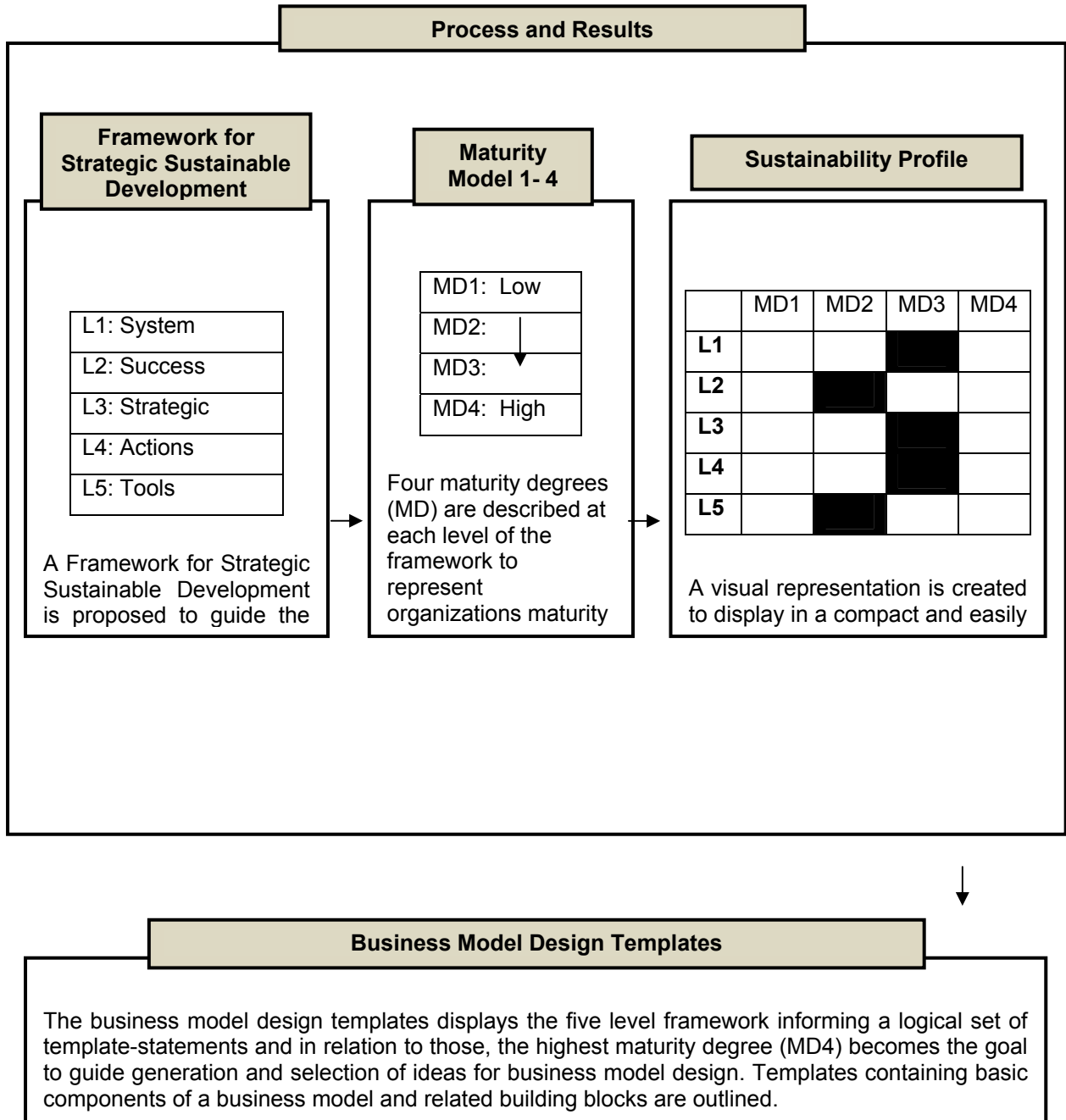
### 3. Business Models Design Templates

The business model design templates (Tables 8-12) are similar to the Sustainability Self-Assessment Matrix but with MD4 given as the goal to guide generation and selection of ideas for business models

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design. Templates containing basic components of a business model and related building blocks were outlined.

**Figure 1: Process Overview and Results**




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**Table 2: Sustainability Self-Assessment Matrix - Systems Level**


1 - Systems	Statement	MD 1	MD 2	MD 3	MD 4
Describes the overarching complex system of organizations , within society, within the biosphere in which we are planning and solving problems	The organization has a clear understanding of the operational design of its business models in relation to the environmental and social systems globally (including value chain and all kinds of stakeholders)	We have little or no understanding or engagement with environmental issues and with societal stakeholders in our value chain	We have conducted some environmental and social awareness activities, communication campaigns, and provided ad hoc reporting to some external stakeholders in our business system	We have an extensive repeated and systematic sustainability evaluations within the company in relation to our sustainable vision and have communicated and reported that to some stakeholders	We have an extensive repeated and systematic sustainability evaluation within the company in relation to our sustainable vision and goals, which occurs across the value chain and with other stakeholders – extended enterprise.
<b>Maturity Degree Assessment (E.g.)</b> 					

**Table 3: Sustainability Self-Assessment Matrix - Success Level**


2 - Success	Statement	MD 1	MD 2	MD 3	MD 4
Describes the organization’s intrinsic goal, informed by sustainability principles applied as boundary conditions	The organization has a clear definition of success, including an operational definition of sustainability, and has an understanding of the business case of supporting society’s transformation towards this definition	We have no formal corporate definition of sustainability; the term is used in different ways in different parts of the organization	We have no formal corporate definition of sustainability, however, the term is used in a reasonably uniform way throughout the organization	We have a formal corporate definition of sustainability that has been endorsed by senior management and disseminated repeatedly throughout the organization	We have a formal corporate definition of sustainability based on principles that are: necessary, sufficient, general, concrete and non-overlapping. We have full consensus and buy-in to this from senior management and across all the value chain including joint ventures
<b>Maturity Degree Assessment (E.g.)</b> 					

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**Table 4: Sustainability Self-Assessment Matrix - Strategic Level**


3 - Strategic	Statement	MD 1	MD 2	MD 3	MD 4
Describes strategic guidelines that aid development towards success (including sustainability / success) in the system	The organization has adopted/ developed and built experience in using strategic guidelines that aid development towards sustainability	We do not yet have any strategic guidelines related to sustainable development and consequently no experience in using such guidelines	We have some strategic guidelines related to sustainable development and some experience in using those	We have a set of strategic sustainability guidelines, goals, and experience in applying those for all kinds of investments, repeatedly and systematically across the organization.	We have a full set of strategic sustainability guidelines and goals with extensive experience in applying those for all kinds of investments repeatedly and systematically throughout our operations across the value network
<b>Maturity Degree Assessment (E.g.)</b> 					

**Table 5: Sustainability Self-Assessment Matrix - Actions Level**

4 - Actions	Statement	MD 1	MD 2	MD 3	MD 4
Describes concrete actions and plans of actions (strategies) that are aligned with strategic guidelines to arrive at success in the system	The organization has well-documented concrete business plans that are fostered by strategic guidelines towards its goals and is systematically executing these plans together with relevant external stakeholders in its business system / value network	We have no plans and there have been no or few actions that are fostered by strategic guidelines and a definition of sustainability, and there has not been communication regarding sustainability with stakeholders outside the organization	We have some plans and there have been some actions that are fostered by strategic guidelines and a definition of sustainability, and also some cooperation regarding sustainability with some but not all relevant external stakeholder in our value network	We have plans and plenty of examples of major actions and investments that are fostered by strategic guidelines and a definition of sustainability, and extensive cooperation regarding sustainability with some but not all relevant external stakeholder in our value network	We have plans and there have been actions that involves investments in time and or money that are fully fostered by strategic guidelines and a definition of sustainability, and extensive methodical cooperation regarding sustainability with relevant external stakeholders in the business system
<b>Maturity Degree Assessment (E.g.)</b> 					

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**Table 6: Sustainability Self-Assessment Matrix - Tools Level**

<b>5 - Tools</b>	<b>Statement</b>	<b>MD 1</b>	<b>MD 2</b>	<b>MD 3</b>	<b>MD 4</b>
Describes various tools, methods and concepts used to assess, develop and monitor actions so that that they are aligned with strategic guidelines to arrive at success/ sustainability in the system	The organization makes use of, and informs tools, methods and concepts in a way that supports rational and cohesive use of the systematic approaches outlined in the previous four levels of the framework.	We have a general lack of tools, methods and concepts to support strategic sustainable development	We have some but not a complete set of tools, methods and concepts to support strategic sustainable development and we have a weak competence in how to utilize what we have	We have most of the necessary tools, methods and concepts to support strategic sustainable development, a strong competence in how to utilize each of the tools, methods and concepts and some competence in how to utilize these in a coordinated way	We have a complete set of tools, methods and concepts, all cohesively aligned with our overall business strategy to support strategic sustainable development
<b>Maturity Degree Assessment (E.g.)</b> 					



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Table 7: Sustainability Profile Visualization

FSSD ▼	MD1 [low]	MD2	MD3	MD4 [high]	FSSD ▼	MD1 [low]	MD2	MD3	MD4 [high]
Systems			■		Systems			■	
Success			■		Success		■		
Strategic			■		Strategic			■	
Actions			■		Actions			■	
Tools			■		Tools		■		

FSSD ▼	MD1 [low]	MD2	MD3	MD4 [high]	FSSD ▼	MD1 [low]	MD2	MD3	MD4 [high]
Systems			■		Systems		■		
Success				■	Success	■			
Strategic		■			Strategic		■		
Actions			■		Actions		■		
Tools				■	Tools		■		

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**Table 8: Business Model Design Templates – Targets and Indicators / System level**

<b>1.System</b>	<b>Statement</b>	<b>Goal / MD4</b>	<b>Value network and business systems</b>	<b>Assessments, Targets and Indicators</b>
Describes the overarching complex system of organizations, within society, within the biosphere in which we are planning and solving problems	The organization has a clear understanding of the operational design of its business models in relation to the environmental and social systems globally (including value chain and all kinds of stakeholders)	We have an extensive repeated and systematic sustainability evaluation within the company in relation to our sustainable vision and goals, which occurs across the value chain and with other stakeholders (extended enterprise)	Value Creation and Proposition	Processes, activities, resources, assets
			Value Network and key Stakeholders	Suppliers, customers/ users, relationships, information and material flows
			Return on Investments / Value Capture	Revenue streams costs, life cycle costs, financial aspects and consumption patterns

**Table 9: Business Model Design Templates – Targets and Indicators / Success level**

<b>2.Success</b>	<b>Statement</b>	<b>Goal / MD4</b>	<b>Value network and business systems</b>	<b>Assessments, Targets and Indicators</b>
Describes the organization's intrinsic goal, informed by sustainability principles applied as boundary conditions	The organization has a clear definition of success, including an operational definition of sustainability, and has an understanding of the business case of supporting society's transformation towards this definition	We have a formal corporate definition of sustainability based on principles that are: necessary, sufficient, general, concrete and non-overlapping. We have full consensus and buy-in to this from senior management and across all the value chain including joint ventures	Value Creation and Proposition	Processes, activities, resources, assets
			Value Network and key Stakeholders	Suppliers, customers/ users, relationships, information and material flows
			Return on Investments / Value Capture	Revenue streams costs, life cycle costs, financial aspects and consumption patterns

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**Table 10: Business Model Design Templates – Targets and Indicators / Strategic level**

<b>3.Strategic</b>	<b>Statement</b>	<b>Goal / MD4</b>	<b>Value network and business systems</b>	<b>Assessments, Targets and Indicators</b>
Describes strategic guidelines that aid development towards success (including sustainability / success in the system)	The organization has adopted/ developed and built experience in using strategic guidelines that aid development towards sustainability	We have a full set of strategic sustainability guidelines and goals with extensive experience in applying those for all kinds of investments repeatedly and systematically throughout our operations across the value network	Value Creation and Proposition	Processes, activities, resources, assets
			Value Network and key Stakeholders	Suppliers, customers/ users, relationships, information and material flows
			Return on Investments / Value Capture	Revenue streams costs, life cycle costs, financial aspects and consumption patterns

**Table 11: Business Model Design Templates – Targets and Indicators / Actions level**

<b>4.Actions</b>	<b>Statement</b>	<b>Goal / MD4</b>	<b>Value network and business systems</b>	<b>Assessments, Targets and Indicators</b>
Describes concrete actions and plans of actions (strategies) that are aligned with strategic guidelines to arrive at success in the system	The organization has well-documented concrete business plans that are fostered by strategic guidelines towards its goals and is systematically executing these plans together with relevant external stakeholders in its business system / value network	We have plans and there have been actions that involves investments in time and or money that are fully fostered by strategic guidelines and a definition of sustainability, and extensive methodical cooperation regarding sustainability with relevant external stakeholders in the business system	Value Creation and Proposition	Processes, activities, resources, assets
			Value Network and key Stakeholders	Suppliers, customers/ users, relationships, information and material flows
			Return on Investments / Value Capture	Revenue streams costs, life cycle costs, financial aspects and consumption patterns

**Table 12: Business Model Design Templates – Targets and Indicators / Tools level**

5.Tools	Statement	Goal / MD4	Value network and business systems	Assessments, Targets and Indicators
Describes various tools, methods and concepts used to assess, develop and monitor actions so that that they are aligned with strategic guidelines to arrive at success/ sustainability in the system	The organization makes use of, and informs tools, methods and concepts in a way that supports rational and cohesive use of the systematic approaches outlined in the previous four levels of the framework	We have a complete set of tools, methods and concepts, all cohesively aligned with our overall business strategy to support strategic sustainable development	Value Creation and Proposition	Processes, activities, resources, assets
			Value Network and key Stakeholders	Suppliers, customers/ users, relationships, information and material flows
			Return on Investments / Value Capture	Revenue streams costs, life cycle costs, financial aspects and consumption patterns

### Concluding Remarks

The tool presented in this paper comprises a Sustainability Self-Assessment Matrix that aim to aid clarification of the assessed organization’s maturity in addressing sustainability issues in a strategic way, a Sustainability Profile Visualization that aim to aid a compact and easily accessible overview of the result of the above assessment and a set of Business Model Design Templates that aim to guide generation and selection of ideas for business models design.

From the testing in the case companies we conclude that the self-assessment matrix provided great opportunity for dialogue and clearly exposed opportunities and challenges that exist between the lower and the higher sustainability maturity degrees of the matrix. It also provided guidance for idea generation for how to move towards higher levels of maturity. By using the matrix, the companies were sensitized to an approach that is more strategic and less reductionist. The profile visualization was highly appreciated by the case companies as a way of summarizing the assessment results.

The business model design templates extended the maturity matrix deeper into the value chain and linked to typical business model terminology and at this stage of work with the case companies a range of creativity supporting tools for idea generation were introduced. In one case study, modelling of future energy systems in housing and buildings that followed the creativity exercises triggered insights for prototyping innovative business models, which included aspects such as resources availability, likely future customer preferences and user’s behaviours and lifestyles.

In summary, the case studies provided initial support for the desired ability of the presented tool; to assess and visualize the maturity of an organization from a strategic sustainability perspective and to trigger systematic cooperation for generation and selection of ideas for upstream solutions, new business models and strategic goals and indicators during early phases of the innovation process. Resources for training trainers in using aligned operational support methods and tools were identified as one of the main remaining needs. In future work we will develop such resources and also investigate the possibility of including into the tool itself more user guidance, case study examples and creativity supporting tools.

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## **Sustainable Innovations in Living Labs: Exploring the Potential of a German Research Infrastructure for User-Lead Product and Service Innovations**

Justus von Geibler  
Project Co-ordinator  
Wuppertal Institute for Climate, Environment and Energy  
Döppersberg 19, 42103 Wuppertal  
Germany

Simon Berner  
Researcher  
Fraunhofer Institute for Systems and Innovation Research ISI  
Breslauer Strasse 48, 76139 Karlsruhe  
Germany

Lorenz Erdmann  
Research Associate and Project Manager  
Fraunhofer Institute for Systems and Innovation Research ISI  
Germany

Nino David Jordan  
Junior Research Fellow  
Wuppertal Institute for Climate, Environment and Energy  
Germany

Kristin Leismann  
Project Co-ordinator  
Faktor 10 - Institut für nachhaltiges Wirtschaften gemeinnützige GmbH  
Alte Bahnhofstr. 13, 35390 Friedberg  
Germany

Christa Liedtke  
Director of Research Group 4: Sustainable Production and Consumption  
Wuppertal Institute for Climate, Environment and Energy  
Germany

Holger Rohn

Director

Faktor 10 - Institut für nachhaltiges Wirtschaften gemeinnützige GmbH

Germany

Kathrin Schnalzer

Research Fellow

Fraunhofer-Institute for Industrial Engineering IAO

Nobelstraße, 70569 Stuttgart

Germany

Matthias Stabe

Research Fellow

Fraunhofer-Institute for Industrial Engineering IAO

Germany

### **1. Living Labs for sustainability innovations – exploring the potentials**

The sustainability potentials of many product and service innovations regularly fail to realise because they are not sufficiently tailored to the needs of users or are not handled correctly. Unexpected user behaviour with more efficient goods and services can also lead to ecologically problematic increases in consumption. This is known as a form of rebound effect. The inclusion of users in an early phase of the development of products and services, such as design or even problem definition, can help to address these problems.

The project consortium *Sustainability Innovations in Living Labs* aimed at identifying the potential contribution of integrating users for the successful generation of sustainability innovations. Based on this, potentials of and measures towards the realization of a German research infrastructure for the integration of users into sustainability-oriented product development were identified. These measures are intended to contribute towards a significantly more efficient utilization of resources within the spheres of production and consumption.

### **2. Methodology**

This analysis of the potentials of a German Sustainability Living Lab research infrastructure for the user-lead development of sustainable products and services, as well as preconditions for its realization, is based on the concept of innovation and technology analysis (ITA). ITA is a strategic concept for the analysis and evaluation of technologies that integrates research with practical considerations (BMBF, 2001). The integration of relevant experts and stakeholders in discussions concerning innovations and new technologies is an important part of this approach.

The research was conducted in three steps: First, the German research and development (R&D) landscape was screened for suitable extant points of departure for the development of such a research infrastructure. Here, about 15 experts were interviewed or consulted. In a second step, technologies, products and services that promise a high potential for benefiting from user integration in the innovation process were identified. In a third step, the drivers and barriers for a functioning German Sustainability Living Lab infrastructure were conceptualised. Here, five additional experts were interviewed. Each step benefited from discussions with experts in two workshops.

### 3. Points of departure for the development of a Sustainability Living Lab infrastructure in Germany

#### 3.1 The status quo

First of all, an exploration and analysis of the *status quo* was conducted. To this end, Living Labs in German-speaking and neighbouring countries were identified and a related landscape drawn. The list of Living Labs was prioritized prior to further analyses. Qualitative interviews with representatives from eleven labs were conducted and evaluated.

In general, the German Living Lab landscape turned out more heterogeneous and less densely populated than expected prior to analyses.

With the Living Labs explored, sustainability aspects were not considered to be a core interest. The sustainability concept was also not clearly defined. Activities mostly focus on economic or business issues, e.g. on the development and diffusion of technological innovations, or on social aspects, e.g. maintaining autonomy and inclusion of the elderly in society. So far, ecological aspects are addressed only rarely, e.g. regarding energy consumption and resource efficiency.

Living Labs seem to be a promising approach for supporting sustainable development in Germany. An important precondition for this to succeed – not least in order to enable the validity of the prior statement – would be a conceptual clarification of the meaning and implications of sustainable development.

The challenges that would arise from observing sustainability effects and interacting with users and/or stakeholders in locally as well as temporally distributed ways cannot be sufficiently confronted by current Living Labs.

Once these challenges are overcome, the utilization of Living Labs may well serve as a mediation instance to communicate issues of sustainable development to a wider public.

When asked about conditions supportive for actually operating and using Living Labs, experts indicated that long-term, topically rather open-ended and thematically flexible funding schemes that do not force premature focussing on product commercialization would be helpful. Living Lab research was seen rather as basic than applied. Moreover, there is a need of developing concepts regarding sustainable development that can be meaningfully implemented and operationalized *via* Living Labs in real-life fields of application. Practically, start-up (seed) financing and operationally viable business models would have to be elaborated, too.

As a future scenario for Living Labs for Sustainable Development, location-based conventional research facilities could well be complemented with mobile and/or temporary research settings to operate in real life locations of specific interest. This would have to be supported methodologically, e.g. *via* ethnographic approaches to address locally and temporally disperse phenomena, respectively.

As sustainability inherently involves distributed phenomena, networking on both national and international scales should be cultivated. This should also include the further development of competences concerning cross-cultural and cross-disciplinary comparative analyses and concept development amongst highly diverse collaborators.

#### 3.2 What areas of application promise the greatest sustainability potentials?

The potential analysis conducted identified relevant application areas for Living Labs for Sustainable Development and takes sustainable development as a multidimensional concept (social, ecological, economic, cultural). Based on the analysis of the living lab infrastructure of Germany (AP 1) it was revealed that topics such as safety, energy consumption and product functionality are widely popular, and at the same time topics such as resources and environmental dimensions of sustainability are neglected. Therefore, the research adopted a narrowed down focus on the reduction of natural resource consumption (resource efficiency), instead of the complete range of sustainability effects. The following hot spots were identified:

- Living and working
- Towns and Region
- Commerce and restaurants



The analysis shows that there are many potential application areas for Living Labs for Sustainable Development, as well as a requirement for differentiating between the two complementary research perspectives “**user behaviour**” and “**product innovation**”

The field of **product innovation** focuses on the development of product groups that are resource-efficient and sustainable along the entire value chain. Due to a closer user involvement in the innovation process, in the diffusion phase the user acceptance of products and services can be increased significantly. This applies to products and services with positive as well as negative potentials for sustainability. Therefore, it is important to ensure that the diffusion success of sustainable products and services is promoted by integrating users in the innovation. Living Labs offer one of several ways of closer user integration. They aim at optimizing products by involving users in the innovation process. This application area is interesting for (especially. manufacturing) companies, because it focuses on product innovation.

Regarding **consumer behaviour** the change of the user's behaviour towards more sustainable lifestyle and consumption patterns is of special interest. By simulating a realistic living-environment within the Living Lab, the systemic micro level effects of products and services can be examined and addressed. User acceptance as well as rebound effects can be partly revealed by SLL and innovative solutions can be developed. The aim of this research is to identify behaviours and patterns that can be supporting or hindering factors in the conduct and development of sustainable practices in everyday life. These concepts and approaches can be utilized for directly supporting changes in user behaviour, e.g. in education and communication activities, as well as a basis for research on the development and implementation of product innovations.

#### 4. Drivers and barriers for a Sustainability Living Lab approach

The project identified a number of potential drivers and barriers for the establishment of an infrastructure for the development of sustainability innovations in living labs.

This was done on the basis of a literature review, expert interviews and workshop discussions. Based on the innovator role model of Hausschild und Gmünden (2007) factors potentially affecting the implementation of the envisaged living lab infrastructure were categorised as pertaining to the realms of expertise, power, process, and relationships.

The following **expertise-related factors** seem to be particularly **beneficial** for the development of an SLL infrastructure:

- Systematic utilisation of sustainability indicators and assessments.
- A long-time horizon.
- High case numbers.
- A sensitivity to cultural barriers that could be in the way of considered socio-technical approaches towards more sustainable patterns of production and consumption.

The following **expertise-related factors** seem to be particularly **detrimental** to the development of an SLL infrastructure:

- Time-constrained and reductionist research designs.
- A lack of competency for inter- and transdisciplinary communication among researchers and between researchers and users.

With regard to the role of **power-related factors**, it seems necessary to ensure long-term public financing due to the high share of basic research to be conducted. At a more general level, it seems advantageous to have a regulatory framework that:

- Drives business to internalize formerly externalized costs.
- Protects niches for innovative activities (particularly in order to guard from premature commercialisation and lock-in).
- To implement measures for the protection of unbiased, technology-neutral and sustainability oriented research.

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From a **power perspective** the following **barriers** can be identified:

- Short time horizons and premature or special interest-led choices for specific technologies
- Extant product-centric business models that are opposed to the implementation of systemic, resource-efficient innovations
- Unwillingness to make the impact of technologies comparable or the desire to merely advertise specific products
- Low visibility of living lab potentials stands in the way of broader reception at the communal and regional political levels
- Rivalry in the research and development field can stand in the way of open innovation processes
- Undue advantages for specific technologies as a result of exclusive public support for specific experiments

With regard to process aspects, it seems advantageous to:

- Ensure sufficient freedom for developers so that they can enjoy creativity and the willingness to take risks.
- It also seems advisable to work towards a dynamic support for those solutions that exhibit the most promising development patterns by establishing an evaluation framework that works in proximity to the process.

Barriers can be seen in the:

- High burden of time and effort that need to be invested in ensuring optimal assistance for and interaction with the users.
- Risk averse funding principles of public funding bodies that are not ideally tailored to the needs of innovative and sustainability-oriented activities.
- A lack of the flexibility that is needed in order to support or participate in dynamic innovation processes that include a wide array of different actors.

Regarding relational aspects, it is important to:

- Keep users motivated.
- To test and support, if necessary, their ability for reflecting on their behaviour.

Thus, the social relations to users should be at the centre-stage of living labs for sustainable development. In order to ensure this, someone should take on the form of a moderator.

On the other hand, companies' focus on technical functionalities and their lack of appreciation for research on users' acceptance of products and services poses an important barrier to the success of living labs.

## 5. Discussion

Different expert cultures and terminological barriers between social science and humanities, on the one hand, and technology-oriented sciences, on the other hand, can make cooperation in living labs difficult. At the same time, the transdisciplinary character of living labs poses a barrier for their inclusion into the science system. For the successful implementation of living labs for sustainable development it will be necessary to integrate sustainability research, design, innovation and technology studies, social sciences and cultural studies. Living labs could provide a good opportunity for furthering exchange between the design discipline and more scientifically oriented disciplines. Living lab research also provides a good way of integrating perspectives on real world utilization patterns in ecological product assessments.

In order for living labs for sustainable development to fully leverage their potential impact it seems important to work towards an integration of dynamic feedback processes that support reflexive learning and goal adjustment.

Living labs for sustainable development can be seen as part of the transition from a Mode 1 (hierarchical, disciplinary, academic) to a Mode 2 research system (anti-hierarchical, transdisciplinary,

heterogeneous) (Gibbons, 1994), due to their inclusion of a range of different actors, their network character and their field of application.

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## Eco-Innovation and Resource Efficiency

Luca Venerando Giuffrida  
Director General For Environment  
European Commission  
Unit E.4 LIFE Environment & Eco-innovation  
Brussels  
Belgium

### Abstract

Economic development over the past century has largely been based on an intensive and increasing use of natural resources. Global trends of population growth, depletion of natural capital, increasing prices of key resources and greater price volatility coupled with the substantial import dependency of the EU economy put a break on that growth model. Continuance of current patterns of production and consumption is not an option.

In response to these challenges, increasing Resource efficiency will be key to securing growth and jobs for Europe and will help us achieve many of the EU's objectives. Resource efficiency is about cutting the link between economic growth and resource use, pollution and greenhouse gas emissions. This concept means using the Earth's limited resources in a sustainable manner, while minimising impacts on the environment. Sustainable resource use is the condition of long term resilience and competitiveness for our economy, a source of growth and jobs, which offers multiple benefits and market opportunities for business.

The Resource-Efficient Europe flagship initiative is a pillar of the Europe 2020 Strategy for a smart, inclusive and sustainable economy. The Roadmap to a resource efficient Europe, which is one of the main building blocks of that flagship initiative, sets out a framework for the design and implementation of actions towards a resource efficient Europe. The Roadmap highlights the potential, opportunities and benefits of resource efficiency. The key message of this agenda is to start exploiting greener sources of growth and become more resource efficient now, rather than wait until we are forced to by collapses, resource shortages and price-hikes.

Eco-innovation can lead the way to a resource efficient Europe. It promotes the introduction of new or significantly improved products, processes, or organisational changes that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle. Traditionally, eco-innovation was understood mostly as a solution to minimise or fix negative environmental impacts from production and consumption activities. It is increasingly evident today, however, that the key challenges of the 21st century are not only about reducing pollution, but also about changing the ways we produce and consume, manage and safeguard our natural resources.

The Eco-innovation Action Plan is a follow-up of Innovation Union flagship initiative, although it complements other flagship initiatives, including Resource Efficient Europe. This Plan, which is the Commission political answer to the challenge of a more inclusive and greener economy, aims at boosting innovation that results in or aims at reducing pressures on the environment and to bridge the gap between innovation and the market.

## Resource Management and Technological Innovation

Sasha Hermann

Director

VDI Zentrum Ressourceneffizienz GmbH

Johanniststr. 5-6

10117 Berlin

Germany

### Abstract

Global resource consumption increases continuously. At the same time the natural raw material reserve base is continuously decreasing. Therefore, resource efficiency has become a topic of great importance. A company that is not able to efficiently utilise its resources is less competitive and less sustainable. Successful economies depend on the reliable availability and on a limited price volatility of raw materials for manufacturing. Entire value chains can be threatened by shortages in supply, caused by price volatility and deficient exploration activity.

Using resources in a smarter and more intelligent way is a precondition for the maintenance of our current life style – wealth, education and general satisfaction. Different policy elements might accelerate the development towards more resource efficiency. Therefore the German government sets the aim in its *National Sustainability Strategy* from 2002 to double resource productivity between 1994 and 2020. On a European level, the *Roadmap to a Resource Efficient Europe*, launched in 2011, does emphasis on decoupling growth from resource use. Recently, in February 2012, the *German Resource Efficiency Programme* (ProgRess) was adopted by the Federal Cabinet. The goal of the Programme is to structure the extraction and use of natural resources in a sustainable way and to reduce associated environmental pollution as far as possible. ProgRess gives an overview of numerous existing activities and describes approaches and measures for increasing resource efficiency along the entire value chain. Raising resource efficiency in production is one of the key issues of ProgRess since material costs with around 43 percent make up the biggest share of the cost structure in the manufacturing sector in Germany. Furthermore, especially Small and Medium sized Enterprises (SME) show a high grade of innovation ability which is normally required for resource efficiency measures.

There is a range of knowledge how to increase resource efficiency in production existing, e.g. best practice examples, successful technical innovation and numerous research projects. However, this knowledge is still comparatively rare, not communicated and thus scarcely accessible. Hence, the diffusion of resource efficient technologies is slow, especially in SME. This is only one example of several types of barriers for realising more resource efficiency that have to be overcome. Other obstacles are the lack of awareness of SME for the potential of cost reductions through resource efficiency measures. SME or investors often perceive a high risk that efficiency projects might not pay off quickly enough.

Experiences show, that voluntary offers such as information on resource efficiency technologies, best practice examples and tools supporting resource efficiency are helpful for overcoming these barriers. In order to ensure that resource efficiency knowledge is transferred to SMEs quickly, trainings and seminars, consulting, trade fairs as well as funding are helpful. Organisations such as industrial associations and chambers of commerce have a good access to SME communicating these offers since they are conceived as trustworthy organisations. Since resource efficiency measures are mostly technological innovations, the Association of German Engineers (VDI) obviously is a very suitable partner for spreading the motivation for and the concepts of resource efficiency within the relevant fields along the value chain. Therefore, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Association of German Engineers (VDI - The VDI, founded in 1856, is the largest technical and scientific association with approximately 150,000 personal members in Germany). set up the VDI Centre for Resource Efficiency (VDI ZRE) as project cooperation. ZRE's aim is to promote resource efficiency in SMEs. The main tasks of VDI ZRE are to provide information on resource efficiency and to identify standards of best practice into all fields of technical applications

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with an emphasis on SMEs. The approach of VDI ZRE considers a wide range of strategies for increasing resource efficiency along the product value chain.

After a short explanation of the recent development in Germany this contribution gives a detailed overview of the tools and different measures for enhancing resource efficiency that are offered by the VDI ZRE. Examples of successful innovation provide evidence of the benefits of resource efficiency measures realised in SME. A decoupling of economic growth from the consumption of resources through successfully implementing resource efficiency measures increases the competitiveness of SMEs as well as the competitiveness on a national scale. Thus, technical innovation which is an essential driver for resource efficiency plays an important role in SMEs and contributes to success that is both economic and sustainable.

## A Business Model Framework for Product Life Extension

M.C. den Hollander

Senior researcher

Delft University of Technology, Faculty of Industrial Design Engineering

Delft

The Netherlands

C.A. Bakker

Assistant professor

Delft University of Technology, Faculty of Industrial Design Engineering

Delft

The Netherlands

### Abstract

Product life extension is an increase in the utilization period of products. Design research on product life extension strategies has so far mainly focused on technical aspects of products, like 'prevention engineering' or 'design for repair, maintenance and upgradability', and on individual consumer-product relationships, like 'design for emotional durability'. The viability of product life extension in a business context and the associated consequences for product design, have however remained largely unexplored. In this paper a starting point is provided for this exploration, by outlining the development of a business model framework for product life extension, using strategies for product life extension and mapping these against common elements of contemporary business model theory. Drawing on case studies, examples are used to show how the framework can be used in practice by designers and business developers.

*Keywords:* Business model, product life extension, strategy, product design, resource use

## 1. Introduction

### Background

Product life extension is an increase in the utilization period of products, which results in a slowdown of the flow of materials through the economy.

The last few years, there has been a renewed interest in strategies for product life extension. A recent study by Huisman et al. (2012) showed that material flows through society are accelerating. The average lifespan of products like ICT, white goods, etc., has decreased by 10% between 2000 and 2010, implying an increase in the associated waste streams.

Design research on product life extension strategies has so far mainly focused on technical aspects of products, like 'prevention engineering' (Stahel, 1994) or 'design for repair, maintenance and upgradability' (Nes, 2003), and on individual consumer-product relationships, like 'design for emotional durability' (Chapman, 2009). The viability of product life extension in a business context and the associated consequences for product design, have however remained largely unexplored.

### Research aim and context

Prompted by these recent developments and the current lack of research, we started the research project 'Products That Last' to explore the relationship between business and product life extension.

The central research question is:

*'What are the critical success factors that make longer lasting products feasible in business to business (B2B) and business to consumer (B2C) contexts?'*

As a first step in finding answers to this question, we developed a framework to map out business structures (regardless of venture type) in relation to product life extension strategies, facilitating comparison and pattern recognition.

Here we will present the initial development of this framework and provide examples of how the framework can be used in practice by designers and business developers, drawing on some of the ongoing case studies of the 'Products that Last' project.

## 2. Methodology

A literature review led to the development of a first iteration of a theoretical framework for product life-extension. A workshop with industry was held in order to test its validity and robustness. After refining the framework, we mapped the business models of four companies that successfully promote longer lasting products to further validate the framework and to identify patterns in the way these businesses are organized.

## 3. Results

### Describing business

In order to be able to analyze and compare alternative forms of doing business we needed a set of descriptive parameters with which the essence of any business could be captured. We found this set in the 'business model' concept. First coined as early as 1960 (Jones, 1960 cited in Osterwalder, 2004), the term is by now widely used in current management vocabulary when referring to a description of the underlying structure of a business and has proven valuable as classifying device for describing, classifying and understanding business phenomena and in developing ideal types (Baden-Fuller and Morgan, 2010). Basically, *'a business model describes the rationale of how an organization creates, delivers and captures value'* (Osterwalder and Pigneur, 2010).

### Capturing business structure regardless of venture type

After extensive research of existing business model descriptions, Osterwalder arrived at nine *'building blocks'* that could be used to describe any business venture (Osterwalder, 2004).

In his more recent book 'Business Model Generation', coauthored by Yves Pigneur, these nine building blocks are described in their latest reincarnation (table 1), the result of careful reviewing, testing and refining together with a community of over 470 practitioners in 45 countries (Osterwalder and Pigneur, 2010). It is this version we have adopted for our framework.

Building block	Description
Customer Segments	The different groups of people or organizations an enterprise aims to reach and serve.
Value Proposition	The aggregation of features and benefits that create value for a specific Customer Segment.
Channels	How a company communicates with and reaches its Customer Segments to deliver a Value Proposition.
Customer Relationships	The types of relationships a company establishes with specific Customer Segments.
Revenue Streams	The income a company generates from each Customer Segment.
Key Resources	The most important asset required to make a business model work.
Key Activities	The most important things a company must do to make its business model work.
Key Partnerships	The network of suppliers and partners that make the business model work.
Cost Structure	All cost incurred to operate a business model.

Table 1. The nine business model building blocks from 'Business Model Generation'.



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Integrating strategy and operations more closely with the business model ontology

In their study 'The entrepreneur's business model: toward a unified perspective', Morris et al. (2005) analyzed over 30 definitions of the term 'business model' and their respective components. This analysis led them to propose a triple layer framework for business models.

Their proposed 'foundation level' is shaped by strategic decisions, primarily aimed at determining what a business is and is not and ensuring these decisions are internally consistent. The outcomes of these essential decisions provide us with a generic basis for comparison across different kinds of businesses and allows for recognizing basic business model patterns.

At the next level, the 'proprietary level', we find the tactical decisions that determine the unique marketplace advantage and identity, the fingerprint so to speak, of a business.

Finally there is the 'rules level', containing detailed operational decisions that determine how the defining outcomes of the two previous levels are preserved and expressed in day-to-day operations.

Where Osterwalder (2004) distinguished a strategic layer, a business model layer and an operational layer and chose to keep them separated, the multi-layered framework by Morris et al. (2005) offers a way to more closely and seamlessly integrate the three (fig. 1).

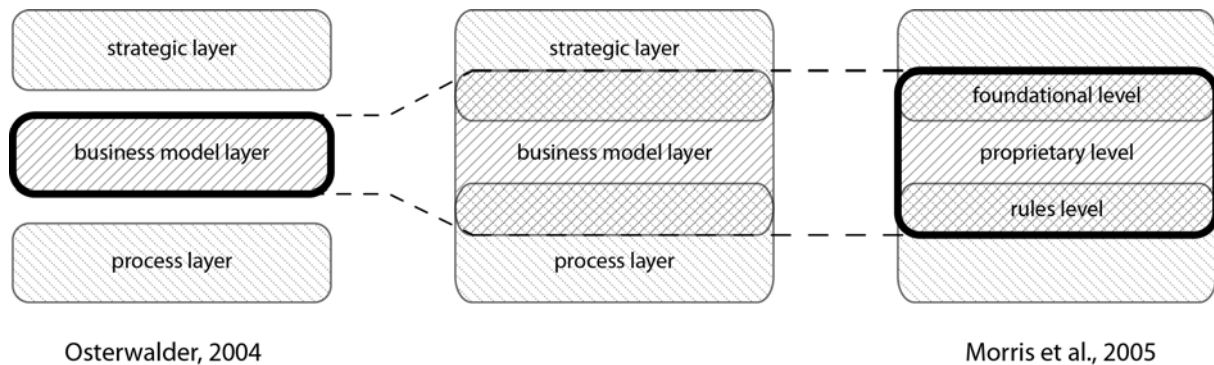


Figure 1 Expanding Osterwalder's (2004) narrower business model layer into the triple layer framework by Morris et al (2005).

The reason for incorporating (at least part of) this strategic layer, is that Cooper et al. (1999) have found, in their research on new product portfolio management, that businesses who manage their portfolio based on their business strategy are the most successful. As this might also be the case for successful businesses around product life extension, we wanted our framework to be able to reflect this.

### Describing Product Life Extension

In order to come up with a set of non-overlapping strategies for product life extension, we built on research by Linton and Jayaraman (2005), in which they systematically catalogued different modes of product life extension.

Although we have chosen to adopt large parts of their classification of product life extension strategies, including many of the definitions, as basis for our set of product life extension strategies, we introduced some modifications.

We added:

- 'Product integrity' as a concept and ordering principle. Building on the concept of 'Product identity' as introduced by Linton and Jayaraman (2005), we defined the level of integrity of a product as being at its peak right after its production and being at its lowest (but not zero) when reduced to its component parts. According to our definition, the point of zero integrity is reached when a product loses all of its original geometry (i.e. shredded or melted down).
- 'Product attachment', as van Nes (2003) has shown the positive influence of an emotional bond between user and product on preventing, or at least postponing, product replacement.

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- 'Product durability' as a product life extension strategy: making products that are inherently designed and built to last;
- 'Standardization', as making use of standardized components should facilitate reparability because of wider availability of interchangeable parts, both over time and from different manufacturers;
- 'Product pooling/sharing' (Tukker, 2004), since shared use of a product could contribute to a more effective use over time.

We merged:

- 'Preventative maintenance' and 'Predictive maintenance' into 'Maintenance' because the two are closely related ('predictive maintenance' is essentially condition driven 'preventative maintenance'). If need be, they can easily be re-differentiated in later stages (proprietary level and rules level).

We removed:

- 'Recall' as a product life extension strategy, because we consider it a contingency measure;
- 'Recycling', because it operates on a material level and completely destroys original product geometry, thereby reducing product integrity to zero.

### Product Life Extension Strategies defined

Product life extension strategy	Definition
<b>Product attachment</b>	The strong emotional connection users feel to a product, due to the service it provides, the information it contains, and the meaning it conveys (Chapman, 2009).
<b>Product durability</b>	The ability of a product to perform the function(s) it was designed and built for over a long period of time without breaking down and without showing inordinate amounts of wear and tear.
<b>Standardization</b>	The provision of products and their parts with more interchangeability than is logically necessary (Farrel and Saloner, 1985).
<b>Product pooling/sharing</b>	The use of a product by two or more users, either at the same time (pooling) or sequentially (sharing) (Tukker, 2004).
<b>Product reuse (direct)</b>	The use of a product in its same form for the same use without remanufacturing (Kopicki et al., 1993, p. 3 cited in Linton and Jayaraman, 2005, p. 1815).
<b>Maintenance</b>	The performance of inspection and/or servicing tasks to retain the functional capabilities of a product (Smith, 1993 cited in Linton and Jayaraman, 2005, p. 1814).
<b>Repair</b>	The restoring of a product to a sound or good condition after decay or damage (Flexner, 1987 cited in Linton and Jayaraman, 2005, p. 1813).
<b>Upgrading</b>	Improving the quality, value, effectiveness or performance of something (Flexner, 1987 cited in Linton and Jayaraman, 2005, p. 1814).
<b>Remanufacture</b>	The restoration of used products to a like-new condition, providing them with the performance characteristics and durability as least as good as the original product (Lund, 1984 p. 1 cited in Linton and Jayaraman, 2005, p. 1815).
<b>Part reuse</b>	The use of a part in its same form for the same use without remanufacturing (Kopicki et al. 1993: 3 cited in Linton and Jayaraman, 2005, p. 1815).

Table 2. Product life extension strategies in order of descending product integrity.

### Mapping and visualizing

We next devised a way to visually map both the foundational business model level of a business and the application of product life extension strategies by that business in a single diagram.

### Business Model mapping

For the business model representation we modified the basic nine axis diagram as proposed by Osterwalder (2004) to represent his more recent version of the nine building blocks and ordered them

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in line with the 'Business Model Canvas' (BMC) diagram (Osterwalder and Pigneur, 2010). We arrived at the scoring values for each of the nine axes by condensing the detailed options within each of the building blocks as summed up by Osterwalder and Pigneur (2010), into a dimension we assumed potentially relevant to product life extension and that would not exclude any of the wider option content.

The scoring values were placed in such a way at the respective ends of each axis as to minimize the number of 'star shaped' graphs resulting from our test plots in favor of more 'rounded blob' graphs (fig. 3), thus providing the clearest visual shift between graphs of business models that promote product life extension and those that don't.

Axis label	BMC	Axis value 1	Axis value 2
<b>Value proposition</b>	VP	Single dimension: for example 'lowest price' or 'smallest' or 'fastest' whilst otherwise mostly similar to competition.	Multi dimensional : a composite value proposition, for example 'efficient' and 'lifelong warranty' and 'small'.
<b>Customer relationship</b>	CR	Shallow: no contact beyond time of purchase, customers are anonymous and interchangeable	Deep: mutual exchange of information, contact beyond time of purchase, recognition of individual customer
<b>Channels</b>	CH	Single phase emphasis: Channels for one product lifetime phase, for example 'purchase phase' are highly developed whilst channels in the 'after-use' phase are not	Multi phase balance: Channels for each of the product lifetime phases are equally well developed
<b>Customer segments</b>	CS	Low level of segmentation: Little or no criteria for differentiation between groups of potential customers	High level of segmentation: Complex of criteria for differentiation between groups of potential customers
<b>Revenue streams</b>	R\$	Over time: For example through leasing, pay-per-use or subscriptions	One time: Most often through transfer of ownership
<b>Cost structure</b>	C\$	Value driven: Aimed at creating premium value propositions	Cost driven: Aimed at minimizing cost wherever possible
<b>Key partners</b>	KP	Strategic: Long term relationships based on mutual strategic fit	Buyer-supplier: Transactional relationship, centered around product price, availability and terms of sale
<b>Key resources</b>	KR	Soft: People (attitude and skills) and intellectual property	Hard: Physical assets and financial resources
<b>Key activities</b>	KA	Services	Manufacturing

Table 3. Axes labels and scoring values for business model diagram

### Product Life Extension Strategy mapping

For product life extension strategies we chose a linear mapping device, representing the linear ordering by 'product integrity' we introduced earlier. The mapping represents the relative level of application by a business for each of the ten strategies, where higher means more (fig. 3). The resulting graph now has whole product related strategies to the left (I), intervention related strategies in the middle (II) and (dis)assembly related strategies to the right (III) (fig. 3).

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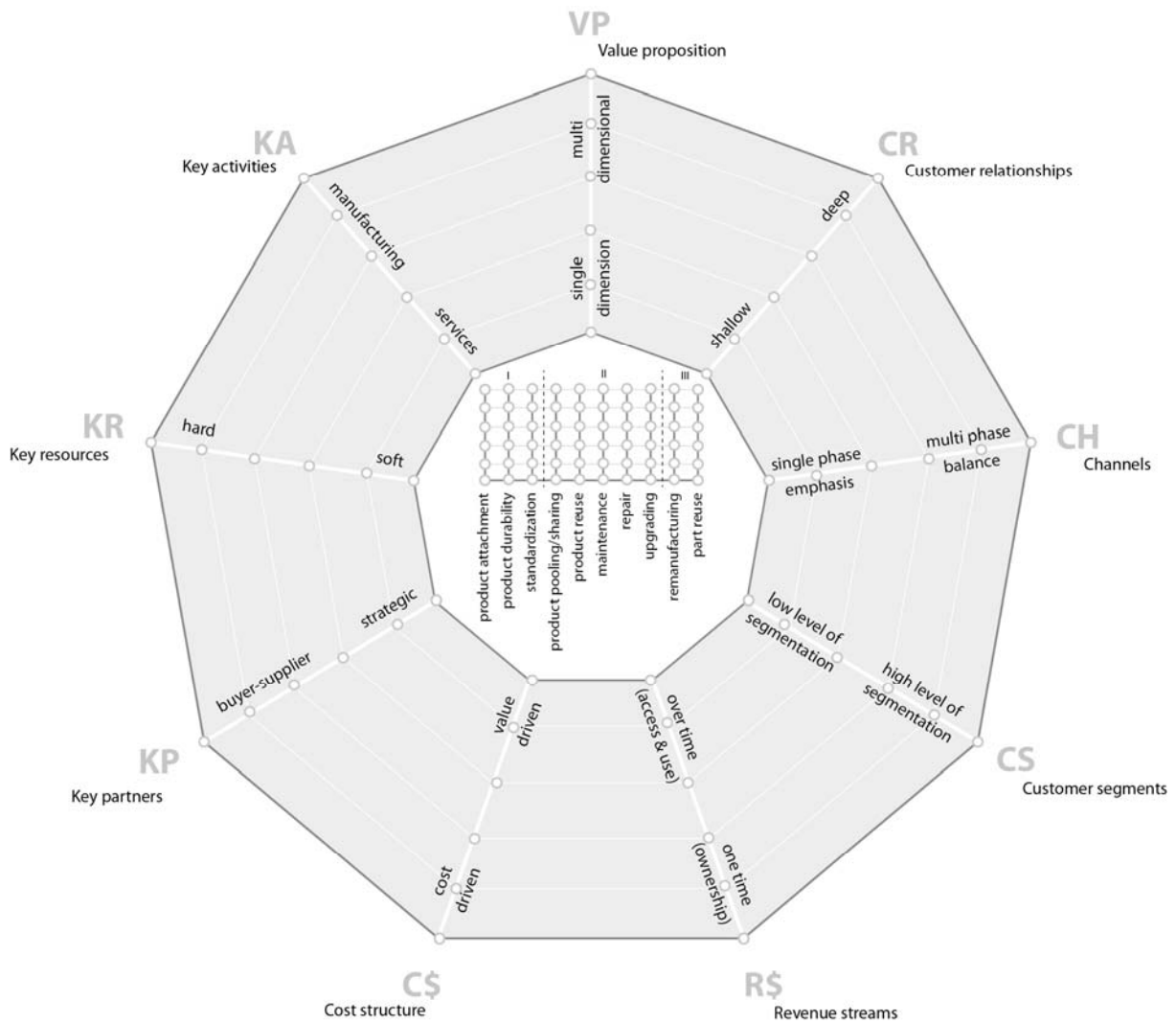


Figure 2 Integrated business model and product life extension diagram for visual mapping

### Case study examples

We have mapped out four businesses that promote longer lasting products in different sectors onto our diagram. The businesses and the means by which we acquired the information needed for mapping are listed below (table 4.):

(Detailed case study descriptions will be subject of a future research paper.)

Company name	B2B/B2C	Product	Method of acquiring information
BMA Ergonomics	B2B	Office chairs and furniture	Interview
Miele Nederland	B2B/B2C	Household appliances	Interview (diagram filled out by employee)
Océ Technologies	B2B	Copiers, printers and plotters	Interview and workshop
Vitsoe	B2B/B2C	Wall shelving	Website analysis ( <a href="http://www.vitsoe.com">www.vitsoe.com</a> )

Table 4. Case study: four businesses that promote longer lasting products

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The resulting diagram, when filled out is shown below (figure 4):

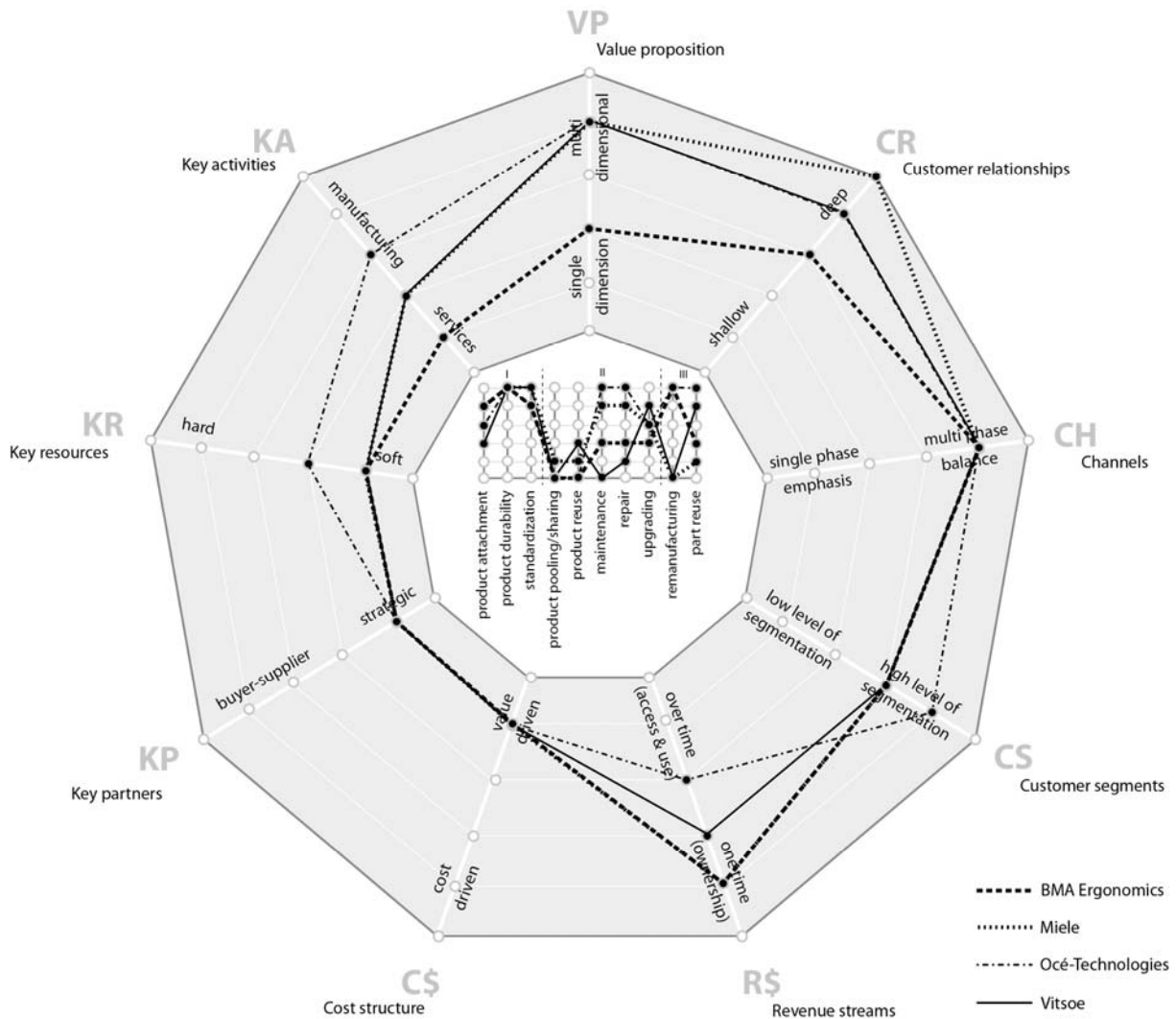


Figure 3 Case study: four businesses that promote longer lasting products mapped out in diagram

### 4. Discussion

From the diagram it is clear that, even taking into account errors in interpretation of the interviews or the website material, both the business models and the spectra of product life extension strategies of the companies seem to have a lot in common, at least at this level of analysis.

The companies tend to (with regard to their business model):

- not compete solely on price (multi dimensional value propositions in conjunction with the remarkable absence of 'cost driven' cost structures);
- stay connected with their individual customers (deep customer relationships);
- be visible to and available for communication with customers over the whole product life cycle (multi phase balanced channels);
- tailor their offering to well defined segments of the market (high level of segmentation);
- have 'value driven' cost structures
- maintain lasting strategic relationships with their partners (strategic key partnerships);
- view their human resources and intellectual property as essential (soft key resources); and (concerning product life extension strategies),

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- strive for intrinsic product durability to start with (strategies from category I);
- apply not just one, but a combination of product life extension strategies;
- focus more on repair, maintenance and remanufacturing as the product gets more complex;
- shun direct product reuse, especially those companies with more complex products. The reason Miele gave for this was that their brand name could suffer damage because the quality of reused, sometimes modified, products is quite unpredictable, depending on factors outside Miele's control;

We believe the combination of the most recent version of Osterwalder's business model ontology (2010) with the triple layer framework by Morris et al. (2005) provides us with a well defined, but at the same time almost organic, organizational principle for progressively mapping out the structure of a business, from an initial overview down to any level of detail needed for our future research.

The non-overlapping set of product life extension strategies we have assembled, covers the full spectrum of possible interventions over the lifetime of a product, from design intention to part and (reverse) logistics related strategies.

Of course, the results we presented cover only the foundation needed to systematically explore and analyze the complex relationship between product life extension strategies and business models. Further research and more detailed case studies will be necessary to provide the content to this framework at all levels, hopefully enabling us to discover emerging patterns and to identify the critical success factors that make longer lasting products feasible in B2B and B2C contexts.

## 5. Conclusion

In this paper we have outlined the development of a framework for exploring the relationship between product life extension strategies and business models and illustrated the use of a visual mapping device, quite literally offering us initial insights into patterns emerging out of the complex relationship between product life extension strategies and business models.

## Acknowledgements

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# Life Cycle Thinking and Integrated Product Deliveries in Renovation Projects: Extending the Concept of Integrated Product Deliveries with Product Service Systems

Jan Schipull Kauschen

PhD-student, Architect MAA, Dipl.-Ing. Arch. (TU)

Royal Danish Academy of Fine Arts, School of Architecture

Centre for Industrialised Architecture (CINARK) and JJW arkitekter

Copenhagen

Denmark

## Abstract

With a large potential energy savings achievable through extensive renovation of the existing residential building stock, and ownership of dwellings built from 1960-75 consolidated in relatively few social housing companies, who are potential agents of change in the construction industry as a whole through the huge building mass they represent.

The examination of contemporary case studies will elaborate on the untapped potential to construct sustainable renovations of existing buildings through extending the concept of Integrated Product Deliveries (IPD) through incorporation of Product Service Systems (PSS) for construction components and services.

A grounded understanding of these concepts will permit independent compatible systems, products and components to fuel further development of socially responsible and robust tools for architects, planners, builders and their clients as they work towards producing sustainable buildings in the future.

## Background

Renovation of existing buildings is one of the most important future tasks for architects, engineers and construction firms. The growing awareness of our society's energy consumption has put renovation and development of the existing building stock high on the list of priorities for politicians and building owners. Recent changes to laws and building regulations defining current and future limits to the energy consumption of buildings reflect this process<sup>1</sup>. In a Danish context this development resulted in two new low-energy building classes, the 2015-class and 2020-class. Both were released in 2011 by the Danish Business and Building Authority<sup>2</sup> to set lower limits to the energy consumption of future buildings, providing a roadmap of legal guidelines to the construction industry with regards to limiting the energy consumption of buildings up to 2020.

The new regulations do not force renovation of the existing building stock, but are playing a key role to create incentives to start renovation projects with a stronger focus on energy consumption. On a societal level a recent study from the Danish Building Research Institute (SBI) calculates potential energy savings upwards of 72% in residential buildings, achievable through extensive renovation of the existing building stock (Kragh and Wittchen 2011, 18ff).

The Danish building stock is unique in that approximately 30% of all buildings were built between 1960-1975. To overcome a severe housing shortage, industrialized building methods<sup>3</sup> were developed and immediately put into practice. Buildings from this period share modular dimensions, materiality, and

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<sup>1</sup> Directive 2002/91/EC of the European Parliament and of the council of 16 December 2002 on the energy performance of buildings.

<sup>2</sup> Translated from Danish: Erhvervs- og Byggestyrelsen (EBST). Since January 2012 under the jurisdiction of the Danish Energy Authority (Energistyrelsen, ENS) .

<sup>3</sup> The period 1960-75 is also called "Montagebyggeri" or "utraditionel byggeri", which can be translated as "prefabricated construction" or "non-traditional construction".



construction technologies as several construction firms developed comparable building systems all utilizing engineer P.E.Malmstrøm 's joint-system developed in the early 1960s<sup>4</sup>.

### Methodology and aim of the study

The research presented has been built-up around a range of renovation project case studies of social housing blocks in Denmark. Projects were chosen to focus the research on state-of-the-art façade refurbishment renovation projects and to document the development of the solutions implemented since the Danish low-energy consumption guidelines came into force.

Cases relevant for this paper are Urbanplanen, Copenhagen (2005-09)<sup>5</sup>, Rækkehusene - Brøndby Strand (2006-)<sup>6</sup> and Heimdsalsvej, Frederikssund (2010-)<sup>7</sup>.



**Figure 1: Case studies, before and after/during renovation**

The research question for this paper – “What is the potential of extending the concept of Integrated Product Deliveries (IPD) towards Product Service Systems (PSS) in renovation projects?” – has been applied to identifying preconditions, client requests and legal barriers in the different case studies. But while all in all cases IPDs have been utilized, it has to be pointed out, that neither of the case studies actually was setup as a PSS. In the case of Urbanplanen a PSS-like situation has recently been achieved, as the construction firm also won a service contract for all renovated buildings for the next couple years.

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<sup>4</sup> P.E. Malmstrøm favoured the idea of an “open system” for prefabricated building, where all construction firms use the same types of joints (and elements) for their building. His jointing system was adopted by the three major Danish construction firms Larsen&Nielsen, Jespersen & Søn and Højgaard & Schultz (Gravesen 1977, 27).

<sup>5</sup> Responsible for planning and construction: Team 100%, joint-venture of JJW arkitekter, Enemærke+Petersen, 3B, Dominia, GHB landskab and Witraz arkitekter.

<sup>6</sup> Client: Brøndby Boligselskab v. Lejerbo, BO-VEST, PAB, BAB/DAB, architect: WITRAZ, construction firm: Enemærke+Petersen.

<sup>7</sup> Client: Boligselskabet Rosenvænget / DOMEA, architect: Mangor&Nagel, construction firm: Jönsson (UNS4/ÖHS, JJW arkitekter, Moe&Brødsgaard).



Figure 2: project stages and responsibilities in case studies and in a possible IPD/PSS scenario

The research presented is formatted as a position paper, with the goals of enabling discussion, motivating further research, and possibly encouraging stakeholders to begin development based on the presented combination of concepts.

### The concept of Integrated Product Deliveries.

Integrated Product Deliveries (IPDs) are complex building products, which integrate such various tasks as planning, product development, production/construction and service/maintenance into a single entity. IPDs encompass both on and off-site works, taking into account all raw materials, building products and labour required for delivery. The advantage lies in the reduction of complexity during the construction process. During the development of an IPD, many non-project-specific tasks are integrated into a single delivery. The product aspect and the work aspect may be seen as integral dimensions of a complex delivery (Vibæk 2011, 75).

In opposition to project-based development, which is “not efficient if know-how is not systematically collected and implemented in future projects” (Beim, Nielsen, and Vibæk 2010, 6), IPDs undergo a R&D process with the aim to make them applicable in a variety of building projects<sup>8</sup>.

IPDs can be regarded in principle as modules joined together with other IPDs (and/or other on-site works) into the final product - the building. These modules require both a specific function and a specific interface to other modules (Hvam, Mortensen, and Riis 2007, 42).

IPDs are thought to reduce complexity as ideally they offer solutions to a specific building need, for example an “indoor climate solution” or a “lighting solution”<sup>9</sup>. As the delivery is fulfilled through its use<sup>10</sup>, the supplier of the IPD should also be responsible for maintaining quality and functionality during the use phase (Mikkelsen et al. 2005, 3).

### The market potential for renovation of multi-storey residential buildings

Figures from Statistics Denmark (DST) and the Danish Association of Social Housing Companies (BL) show that approximately 59% of all dwellings built from 1960-75 are owned by relatively few social housing companies<sup>11</sup>. Roughly 57% of these are multi-storey buildings with similar construction standards using prefabricated building elements typical of their time.

<sup>8</sup> IPDs also represent the knowledge built-up over the course of a variety of construction projects, which leads to more robust building solutions.

<sup>9</sup> For example, an “indoor climate solution” may consist of the facade and a ventilation system, or a “lighting solution” could be a daylighting-optimized window-system, in conjunction with artificial lighting to serve a desired lighting level.

<sup>10</sup> Thereby returning the results of the solution to the owner/user

<sup>11</sup> The National Association of Social Housing Companies (Boligselskabernes Landsforening, BL) has 650 members, of which approximately 540 own multi-storey residential buildings. Social housing companies strongly vary in size. Furthermore, about 70% of all the dwellings in this sector are owned by the 48 social housing companies that are members in “Almennet” (Kirchhoff 2012).

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In general there are two different typologies: in the 1960s, buildings were mostly built with load-bearing inner walls and light facades, while in the 1970s load-bearing facades and light inner walls were favoured, facilitating changes in the apartment's plan.

Despite sporadic renovations over the last 40 years, most of these buildings suffer from severe defects with regard to the construction details and the facades; and as a result, the indoor climate. Furthermore, most of these buildings are lacking adequate insulation and building technology to comply with modern standards of energy consumption. In renovating these buildings there are two foci: façade renovation (energy-focused) and upgrading of the apartments internally (social / usability focus).

Expressed in total figures, there are potentially upwards of 29 million m<sup>2</sup> of living space awaiting renovation in Denmark. This will affect the living conditions of approximately 10% of the Danish population.

These figures show the great market potential for solutions regarding renovation of multi-storey residential houses built in the period 1960-75, which could be executed on the same legal, financial, and technical premises.

### Political perspective and client requests

The potential market for renovation of subsidized housing buildings has already been pointed out by The Danish Agency for Trade and Industry (EFS) in 2000. The report "Byggeriets Fremtid – fra tradition til innovation" ("The future of building – from tradition to innovation") underlines:

The subsidized housing sector should be pioneering construction, and ensure the achievement of the highest quality for the best price, not only in respect to technical and functional qualities, but also qualities such as architecture, accessibility and the minimizing of environmental impacts related to construction. Owners of subsidized housing units should through their building activity help to develop the building sector, help to build-up new skills and promote the new industrialisation of the construction industry. (Erhvervsfremme Styrelsen (EFS) 2000, 67)

The points expressed in the above citation are still valid today (2012) and should be pursued in order to change the way we build towards "sustainable building". Also of note is the identification of "owners of subsidized housing" as potential agents of change in the construction industry through the huge building mass they represent.

Through interviews with representatives from social housing companies, architects and construction companies, I found that clients from the subsidized housing sector require renovation projects to be

1. Financially secure, both for building/renovation cost, and cost from operation
2. Built with high quality craftsmanship and materials
3. Non-disturbing for the residents, meaning that the amount of time a single resident is limited in the use of his/her apartment is reduced to a minimum.
4. Focussed on energy savings to reduce future operational costs
5. Planned for a life cycle of 30 years (the expected financial service life, due to the term of standard bank loans)

These findings stand in a clear contrast to the political perspective from 2000. It seems that today, social housing companies have a strong focus on financial security, which limits their interest in investing into pilot projects or taking part in product developments together with construction firms.<sup>12</sup>

Another barrier is the current "out-dated tender system that excludes the manufacturer from participation in the preliminary phases of a project" (Beim, Nielsen, and Vibæk 2010, 6) and the requirement that a building client may not be bound to a single manufacturer/supplier. In consequence, this situation creates a low incentive for construction firms to invest into the development of renovation solutions, aimed at the social housing sector.

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<sup>12</sup> Interview with anonymous source at the level of a client design advisor in a large Danish housing company, 04.10.2011.

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Another interesting point is that sustainability does not seem to be a parameter for social housing companies. There exists an interest in energy savings and cost-efficiency, but only with regard to securing a project's (and resident's) economy<sup>13</sup>.

Renovation projects of social housing have to be financed mainly through income from rents, with possible financial support from the two major institutions "Landsbyggefonden" (The Danish Building Fund) and "Byggeskadefonden" (The Building Damages Fund). Both institutions are state-owned and may only support eligible renovation projects, and only to the extent as defined by law. In consequence, the financial means are quite restricted for renovation projects in the subsidized housing sector as compared to similar projects in the private sector. This restricts the gamut of possible solutions. This is immediately apparent in the materiality of renovation projects found in Denmark today. Maintenance-free materials such as slate, fibre cement boards and/or glass as façade cladding<sup>14</sup> are the overwhelming preference.

In addition, neither of the two funds may support renovation projects that are undertaken solely to reduce a building's energy consumption<sup>15</sup>.

Another major aspect in renovation projects is the potential interference a renovation project has upon the daily lives and privacy of the residents. There are currently two options available while renovating dwellings:

1. Moving all inhabitants to different apartments, usually not in the same quarter / location
2. Renovating while the buildings are in use

The latter is often favoured, as the moving and administrative expenses are avoided. The disadvantages include a more complicated renovation process, requiring thorough time-planning, and certain types of renovations cannot be executed, such as replacing all interior surfaces or re-planning / adaptation of the dwelling's interior plan. Furthermore, it is required to inform all residents properly and prepare them with regard to the consequences of the building works within their apartments.

Residents of subsidized housing departments are normally offered to take part in hearings during the planning process, or in some way give them the opportunity to express their wishes and to gain some influence on the outcome. Unfortunately, most residents do not choose to inform themselves or take part in the public hearings, leaving the planners and construction firms with the task of contacting and informing residents individually during the renovation project<sup>16</sup>.

Construction firms have identified the management of the resident contact as both productive, in the sense of creating an extra value for both parts, and financially profitable, reducing or eliminating costs resulting from misunderstandings and resulting time delays or court cases<sup>17</sup>.

As a result, we see more and more construction firms streamlining their building process in order to reduce the time that an apartment cannot be used by the tenant. One possible approach is the use of IPDs, with just-in-time deliveries of prefabricated elements to the building site enabling short assembly/erection times due to defined module interfaces and predefined on-site workflows. One example from the earlier named case studies is the renovation of façades. In the Heimdalsvej and Brøndby Strand case studies, deliveries have been used that allow exchanging the façades of an apartment during a single workday (8 hours), including interior finishes -basically while the inhabitants are at work.

Social housing companies currently favour this solution, with winning tenders being construction firms offering this type of façade renovation<sup>18</sup>.

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<sup>13</sup> Interview with anonymous source at the level of a client design advisor in a large Danish housing company, 04.10.2011.

<sup>14</sup> Interview with Sidsel Blegvad og Dag Prestegaard, Witraz arkitekter, 18.06.2012

<sup>15</sup> This fact leads to problem that even recently renovated buildings do not necessarily comply with newer energy standards. As energy consumption is a relevant factor in the budget of social housing companies' alternative solutions, Energy Service Companies (ESCOs) are used to ensure a certain energy-price level, with the disadvantage that the original problem (the high energy consumption of the building) has not been solved.

<sup>16</sup> Interviews with Dag Prestegaard, Witraz arkitekter, 12.06.2012 and an anonymous source at the level of a project manager for a medium-sized Danish contractor, 29.05.2012.

<sup>17</sup> Interview with anonymous source at the level of a project manager for a medium-sized Danish contractor, 29.05.2012.

<sup>18</sup> Interview with anonymous source at the level of a project manager for a medium-sized contractor, 29.05.2012.

### Sustainable Integrated Product Deliveries

There are few IPDs currently on the Danish building market. Some examples are the NCC shaft system, or add-on balconies by altan.dk. But none of the producers or construction firms that have developed IPDs has placed weight on the sustainability of these products. However, a majority of producers claim that the industrialised production approach does create less waste, and that resources are used more effectively than allowed under traditional production methods (Beim, Nielsen, and Vibæk 2010, 161).

One main reason for the little interest in developing sustainable building products is the low price for building materials. In the case of the earlier mentioned façade renovation system, the basic material is timber, which still is cheaper to obtain as new material than recovering it from used façade elements<sup>19</sup>.

For future developments of sustainable IPDs it would be necessary to implement strategies for sustainable production. Most important will be to take the whole life cycle into account and not only the cradle-to-gate stages as done by the earlier named IPDs. Secondly, it will be necessary to calculate and assess the impacts to allow comparison of building solutions.

IPDs may be classified into two basic types: “sustainable by design” and “sustainable by use”. The first focuses on impacts caused by the production processes, used materials and transport<sup>20</sup>, while the second focuses on making the whole delivery more sustainable during the use stage of the building<sup>21</sup>.

### Extending Integrated Product Deliveries to Product Service Systems

Following Oksana Mont's definition of Product Service Systems:

A product-service system (PSS) is

- A pre-designed combination of products and services in a market that can fulfil consumers' needs; and
- A dematerialised solution to consumer needs and preferences; (“leasing” / “service”)
- A result of rethinking of the product value chain and ways of delivering utility to customers that will have a smaller environmental impact than separate products and services outside the system.

(Mont 2000, 35)

A PSS seems to be a promising extension of the concept of Integrated Product Deliveries. IPDs have the advantage of integrating the complexity of planning, designing, producing and installing in one package and are ideally produced in an industrial context. Re-thinking them as services will feed the market with the requested financial security, lower risk when deciding on a certain product, and result in reduced environmental impact due to the greater product responsibility held by the owner of the IPD.

The major advantage of combining the two systems is the incentive created to make the product more robust to be able to serve as a long-time service. Removing the point of sale will encourage the owner of the IPD to alter the product accordingly:

The sale of products does not encourage a closed cycle economy because at the point-of-sale the responsibility for the user phase and the disposal is transferred to the customer; it is the customer who decides what is to happen to the product after use.

The sale provides no incentive for the manufacturer to supply goods, which have a long life or are reusable. (Mont 2000, 35)

The greatest challenge for sustainable architectural projects is the expectation of a long service life for our buildings. This adds a great uncertainty to all solutions we integrate today and especially extended product responsibility can be questioned when discussing use terms of 30 and more years. It is said

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<sup>19</sup> In case of the Brøndby Strand project, it was part of the delivery to recycle building materials from the existing facade elements. Nevertheless, these recovered (and sorted) materials were not reused, but given to a recycling firm.

<sup>20</sup> E.g. a facade element

<sup>21</sup> Such as services that influence user behaviour regarding energy consumption (monitoring systems) or maintenance/tuning services that are carried out in the buildings use stage.

that PSS have mostly been used to replace products with shorter life spans (Mont 2000, 17). Building products and components with planned lifetimes of 20-120 years (windows – brick) will challenge the PSS concept in that respect and result in reinforcing the traditional sale of building components, as no one will be able to give guarantees over such long timeframes. To offset this challenge, IPDs could supplement the PSS as IPDs have a defined interface with other modules, allowing consecutive alterations of the original product without the need of replacing the whole product delivery at one time. The thorough product development needed to create an IPD is one way to allow later disassembly and exchange of single components without questioning the IPD as such. As one example, windows usually are integrally connected with facades today (due to insulation and sealing layers), with the consequence that during replacement adjoining elements are affected and also require replacement, even though their expected service life has not yet expired.

Furthermore, this facilitates the recycling, refurbishing and reuse of the disassembled components as they will ideally be returned to their original producer. If planned correctly, it would be possible to extract clean raw materials for new components from the old. For the future development of IPDs it would be favourable - from a sustainability point of view - to agree on standardized interfaces for modules. This will allow using modules from other producers in case of necessary exchanges, which again will increase the probability of the existence of the needed modules and services in the future, should the original producer no longer exist<sup>22</sup>.

Another positive aspect of using PSS in the building sector would be a true interest in extending the product's lifetime. A more robust product will reduce the efforts needed to maintain the promised function, use less material (due to fewer replacements) and will result in a reduction of maintenance costs (less required service). Developing robust solutions imply a radically different design approach as all life cycle stages have to be considered, with a focus on ease of maintenance, and especially replacement of components. Walter R. Stahel has called this concept "Product –Life Extension"<sup>23</sup> and pointed out that this strategy will allow the "independence of the life-times of inter-compatible systems, products and components" (Stahel 1982, 75). The independence of life-times is one of the major issues in today's constructions, a fact that usually is not taken into account properly during the design stage. Referring to Stewart Brand's "Shearing Layer Strategy" (Figure 3) it is beneficial to think of a building's life-time in layers that will need maintenance or have to be replaced at different intervals (Brand 1995). If layers are interconnected, or worse, locked-in between other layers with longer life-times, the building will in effect be torn apart over its lifetime. This results in much higher renovation costs as layers (or components) are exchanged prematurely. Even more important than the initial higher costs are the increased environmental impacts due to the increased material input<sup>24</sup>.

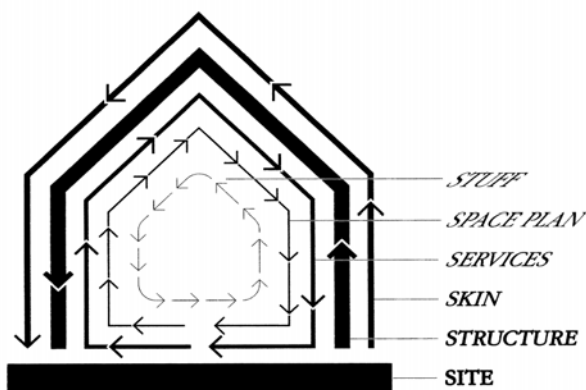


Figure 3: Stewart Brand, The Shearing Layers of Change

<sup>22</sup> With the result of greater investment security, as requested by many clients.

<sup>23</sup> Or also the "Self-replenishing system"

<sup>24</sup> Such as windows that, due to energy regulations, have to be sealed together with vapour barriers in facade constructions. In all case studies presented, windows have been pointed out as the component with the shortest expected life-time, while being built into surrounding materials with much longer life-times (40 years for insulation and vapour barriers, 60 years for the facade-cladding). Exchanging the window results directly in damage to the other layers, as the window components are not independent of other components and no clear interfaces are defined.

Planners are aware of the fact that buildings will undergo various changes in their life-cycle and will have to adapt to changing needs. However, due to the long lifespan the building sector deals with, it is nearly impossible to predict when changes will be necessary and what the consequences for the building will be. Design strategies such as Design for Disassembly (DfD) are new, but rarely used as a requirement in architectural projects. Economics are again responsible for this fact. Planning for DfD implies an increased level of detailing, prototyping and testing of the concepts (mock-ups), including development of destructive-free joints, or other techniques in order to ease dismantling. At the same time, there remains great uncertainty as to whether these concepts will be used. As a consequence the necessary upfront investment becomes questionable. However, pursuing IPDs could be worthwhile, as these deliveries are as industrially manufactured and undergo a product development process before they are implemented in a building<sup>25</sup>. Dominique Millet (2003, 103) has proposed a scale of design concepts with respect to their conceptual ecological quality and the grade of industrialization needed to put them into practice. The diagram (Figure 4) shows that design concepts used by architects as Design for Disassembly or Design for Low Energy Consumption are to be found not only in the past, but can also be regarded as less effective with regard to their reduction in environmental impact. At the other end of the scale we find concepts as Design for Eco-Efficiency, Design for Life Cycle or Design for Sustainability that all are regarded as concepts put into practice with a high level of industrialisation<sup>26</sup>.

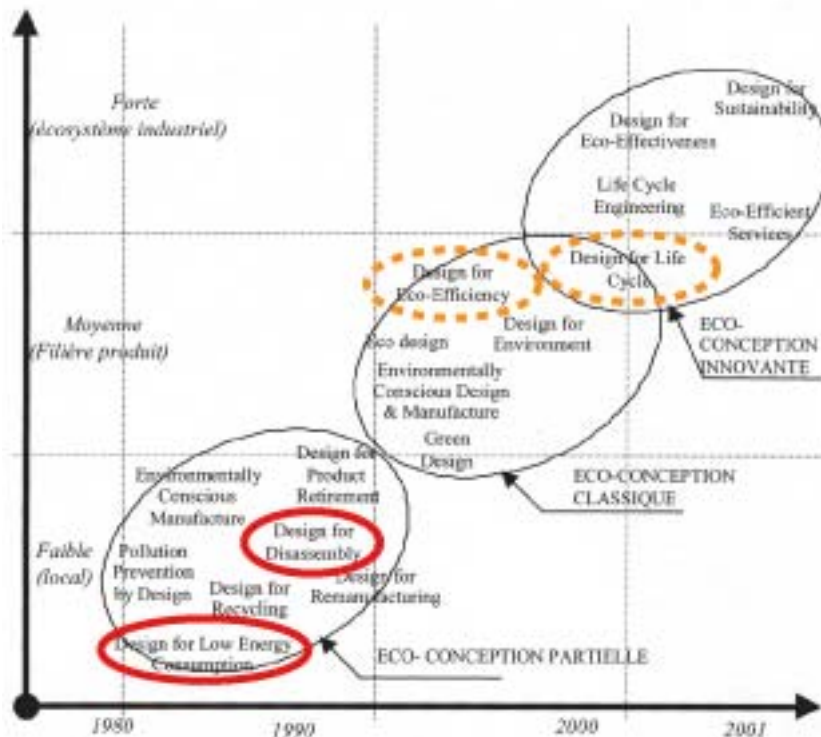


Figure 4: Determination of positions of different eco-concepts in relation to time and the degree of possible reductions of environmental impacts (marked in red: concepts that are used in architectural contexts)

### Business opportunities and stakeholder risk-management

The point of departure for this paper were findings from case studies showing that future financial risks connected to renovation projects are the greatest barrier to initiating renovation projects in the social

<sup>25</sup> In opposition to on-site construction works, there will be a possibility of gathering and implementing the knowledge gained immediately within the same project. In traditional construction works learning takes place sequentially, from one project to the next.

<sup>26</sup> In comparison to architects, car designers currently claim to focus on concepts as Design for Eco-efficiency and Design for Life Cycle with their recent scheme of eco-friendly cars (anonymous source at the level of an environmental planning specialist at a multinational car company).

housing sector. The concept of IPDs as PSS presented would reduce or transfer these risks away from the building-owner and towards construction firms or other third parties that could finance the projects. This raises the question why construction firms should invest in the development of dematerialized solutions and expand their responsibilities far beyond what is regulated by law today<sup>27</sup>. The main advantages for the construction firms are new business opportunities arising from the responsibility for the use and end-of-life stages: maintenance, refurbishment, replacement / upgrading and possible reconditioning and recycling (see also Stahel 1982, 81). The extended responsibility results in a continuous task for servicing the delivery in order to maintain and optimize its functionality. Due to a greater long-term dependency, steady business relations will be established between the client/user and the construction firm, securing jobs and lowering financial risks for the service provider. Reconditioning aging components could also emerge as a new field of operation. Reconditioning includes recovering components from the delivery, re-working or even upgrading them with the goal to reuse them in the same or another delivery. Technical installations are of special interest, as the foreseeable changes in the building code regarding energy consumption will require more frequent upgrades of installations in order to comply with regulations and maintain the systems efficiency<sup>28</sup>.

### Conclusion and further research

Extending the concept of Integrated Product Deliveries towards Product Service Systems appears very promising as it will address the key issues of the renovation task of today– financial security and risk management for both clients and builders. It will also create new business opportunities and strengthen the interest in ecological favourable solutions through emphasising reuse and recycling as key factors within the business model.

Even though none of the interviewed stakeholders had a strategy for integrating sustainability into their businesses, the societal benefits of sustainable renovation could be found in the wake of the other major advantages of the IPD/PSS combination. With a greater focus on extending the product life, the choice of materials will move towards low-impact materials and an extension of the usability stage resulting in fewer replacements when the end-of-life has been defined.

Nevertheless, at present there are many barriers in regards to renovation projects, with the most challenging being the tendering system in the Danish context, as it does not currently allow building clients to partake in a development process in advance of a contractual agreement. The second major issue is the difficulty in securing necessary financing through the Landsbyggefonden, which has to follow strict rules and currently does not finance renovation projects where the main goal is to lower the building energy consumption. Both goals would be required to actually turn the current market potential into a market for renovation projects not solely based on remediating construction defects.

Further research will ideally have a point of departure in a case studies where both IPDs and PSS are combined and have been addressed already early in the planning phase. It needs to be investigated further which building components lend themselves to PSS, and it remains to be proven that industrial production methods actually are beneficial, resulting in lowered environmental impact. With regards to materials, development and testing of design principles<sup>29</sup> for architects could make it easier for planners to integrate the various layers of knowledge needed to develop sustainable buildings.

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<sup>27</sup> The current 5-year guarantee for construction work, longer guarantees for individual components.

<sup>28</sup> The Danish Building Code does not force to renovate or upgrade installations in existing buildings. The concept of PSS might be interesting in this respect, as the system owner will have a stronger incentive to replace outdated components in order to achieve higher revenues on the related energy savings.

<sup>29</sup> Some principles could be: reducing mass, using simple and ecological materials, allow non-destructive disassembly and adaptive reuse of materials as key design parameters.



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## **A Guiding Tool for the Selection of Fish from Sustainable Fisheries for Food Industry, Food Retail and Consumers**

Manfred Krautter

Director

EcoAid

Wiesbaden

Germany

### **Abstract**

Leading companies in food industry and food retail established policies to source fish and seafood from more sustainable sources. In practice, it is still a difficult exercise for businesses to decide which fish is sustainable and which is not. The task becomes even more complicated as they have to take the interests of a broad range of stakeholders into account, e.g. science, non-governmental organizations, fisheries, legal frameworks and certification bodies. This may be one reason why in many food companies the goals for sustainable sourcing of fish and seafood are not properly implemented.

EcoAid has developed a guiding tool for the sustainable sourcing of fish by food industry and food retail. It helps to identify fish from sustainable fisheries. This tool takes into account recommendations and assessments of four NGOs and scientific institutions. It became a implementation tool of the sourcing policy of a leading European retail chain.

### **Global trends towards unsustainable fisheries**

Overfishing is the major problem of global fishery. It has strong impact on biodiversity as well as on food availability. According to FAO the share of fish stocks not fully exploited decreased from 40 to 13 percent from 1974 to 2009. In the same time the share of fish stocks overexploited increased from 10 to 30 percent.

Because of overfishing stocks become less productive. Despite of technological progress in fishing methods, despite of vast expansions of fishing territories horizontally and vertically and despite of expanding fleets, the world wide catch of marine fish decreases after peaking around the year 1998.

As a result of decreasing catches and growing demand, prices of fish have risen much faster than those of meat or grain and are predicted to do so in future. The production of fish and seafood from aquaculture seems to overcompensate the loss of wild catches so far. But as aquaculture of species like salmon or shrimp depend on fish meal and fish oil made from wild fish, new pressures on the wild stocks arise.

Another issue in fisheries is fishing with destructive fishing methods and the generation of high bycatches. E. g. demersal trawl can destroy sensitive ecosystems on the ocean ground and it often generates high bycatches of juvenile fish and non target species. Longline fishery is often criticized because it can cause high bycatches of shark, turtle and sea birds. Many of them do not survive the catch and are thrown back into the sea.

These issues illustrate that there is an urgent need for more sustainable sourcing of fish and seafood in food business in order to protect the marine environment and to secure food supply.

### **Businesses need reliable information on fish and seafood from sustainable sources**

Driven by NGO pressure and own CSR policies many supermarket chains have established policies to source fish and seafood from more sustainable sources. But in practice it is still a difficult exercise for

## Sustainable Innovation 12

businesses to decide which fish is sustainable and which is not. The task becomes even more complicated as they have to take the interests of a broad range of stakeholders into account, e.g. science, nongovernmental organizations, fisheries and certification bodies. This may be a reason why in many food companies the goals for sustainable sourcing of fish and seafood are not properly implemented.

NGO campaigns, media reports, shopping guides and supermarket rankings as those of Greenpeace, Monterey Bay Aquarium, the Marine Conservation Society and WWF proved to have high influence on supermarkets in Germany, the UK or the US. Many retail chains try to take their demands into account. But the advice given by NGOs and other potential references often contradict. E.g. Greenpeace scores all Alaska Pollock fisheries as “red” whereas WWF scores MSC certified Alaska Pollock fisheries as “green”.

A leading German food retailer, the REWE Group, asked EcoAid to develop a guiding tool that is practical and suitable for the implementation of their policy on sustainable fisheries and at the same time takes scientific and stakeholder demands into account.

### **The EcoAid list: A „meta“ guide for the sustainable sourcing of fish**

EcoAid developed such a guiding tool that sets rigid criteria for acceptable fisheries and how they are assessed:

1. Exclusion of endangered species (IUCN redlist and CITES provisions)
2. Consideration of the soundness of the stocks (no fish from overfished stocks)
3. Consideration of the fishing methods and their effects on the ocean environment
4. Comprehensiveness (more than 30 species should be assessed)
5. Up-to-dateness (updates at least once per year)
6. A potential additional criterion in future: Provisions for social fairness and human rights for people working in fisheries and fish processing

### **References**

For this purpose from 13 potential sources five references were selected that fulfill the first four criteria to a large extent and are published by independent NGOs or scientific institutions:

1. Seafood shopping guide of Greenpeace Germany
2. Seafood shopping guide of WWF Germany
3. Seafood Watch Guide of the Monterey Bay Aquarium, USA
4. Fishsource database of the Sustainable Fisheries Partnership (SFP) , Indonesia/ USA
5. IUCN list of endangered species

### **Assessments for 70 fish species and 460 stocks**

We defined about 460 economically important fisheries. Each fishery is characterized individually as the wild catch of a specific fish species in a specific area with a specific fishing method. EcoAid scored these 460 specific fisheries individually by checking the reference lists and databases of the first four organizations for their corresponding recommendation and assessment. In the resulting “meta”-score

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each of the four references was considered equally. Species listed as endangered by IUCN (list no. 5) were rated as “red” in any case. The resulting “meta” score is either:

- Red: not sustainable or
- Yellow: partly sustainable or
- Green: mostly sustainable or
- White: no scoring was possible

If less than two references were available to assess a fishery no scoring took place. If there were two reference assessments/recommendations available that contradicted each other totally also no scoring took place. In such cases we looked for additional references and did more in depth research to find out whether a scoring was possible or not. In this way a “meta” guide was established that combines the assessments of five relevant and internationally active organizations.

### Results

EcoAid evaluated more than 70 species and more than 460 fish stocks and fisheries in this way, including all fish species that are commercially important on the German market.

The resulting scores for the stocks (excluding non-assessable fisheries) are:

49% of the fisheries were rated as “red” (not sustainable)

30% of the fisheries were rated as “yellow” (only partly sustainable).

21% of the fisheries were rated as “green” (mostly sustainable)

The resulting scores for the species are:

For 23 species at least a part of the fisheries are rated as “mostly sustainable” (green)

For 23 species at least a part of the fisheries are rated as at least “partly sustainable” (yellow)

For 24 species all assessed fisheries are rated as “not sustainable” (red)

The EcoAid scoring system also was applied on 95 MSC certified fisheries. The Marine Stewardship Council tries to certify fisheries that fish in a more sustainable way.

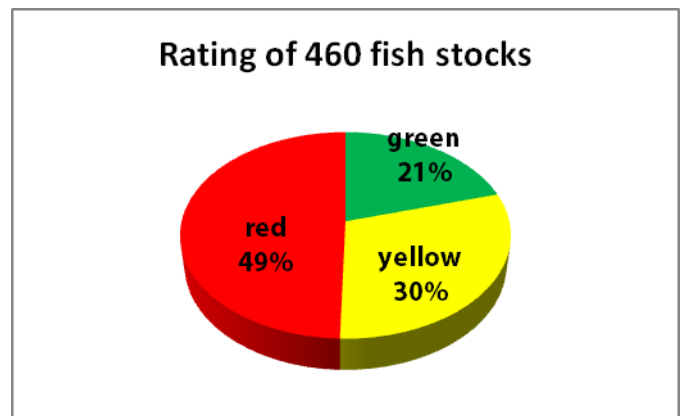
54% of the MSC certified fisheries were rated as “green”

25% were rated as “yellow”

11% could not be rated

Fish industry and retail companies can easily perform a sustainability check of their existing product range with the EcoAid guiding tool. The REWE Group integrated the guiding tool in their policy for sustainable fish sourcing. The company already started improving the sustainability of its fish and seafood product range in a step by step approach.

Sourcing fish and seafood with such science and stakeholder oriented guiding tools contributes to improve the sustainability of the seafood product range of industry and retailers. It also helps to get higher scores in NGO supermarket rankings and to improve a company's reputation.



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# Design for Sustainable Solutions: The Need for Action Beyond Green Design

Dr. Markus Kretschmer  
Professorship of Product Design and Design Management  
School of Engineering and Environmental Sciences  
University of Applied Sciences Upper Austria  
FH OÖ Studienbetriebs GmbH  
Stelzhamerstr. 23  
4600 Wels  
Austria

## Abstract

Design is an important factor of success in today's markets and an influential differentiator for products. Increasingly, sustainability turns out to be another key factor for the success of products. The present study poses the questions that address which success factors mostly influence the sustainability of products and which changes in the field of product design must be made in order to foster these success factors by design in the long range. The primary aim of this study was to provide indications of the truly important factors of success that are capable of being influenced by design. Therefore, semi-structured interviews were conducted to examine experts' views of sustainable development in design. The results confirm that designers are usually neither educated or professionally trained to undertake the areas encompassing the success factors, nor do they have a significant influence on them.

## Problem and Current understanding

Design is a discipline that is strongly linked to industrial production processes and that is a major part of the modern consumer culture. In addition, Design also ultimately influences the sustainability of manufactured products and is in the majority of cases part of complex correlations – but about these correlations there is often not enough knowledge in the management of the innovation process (Esslinger, 2009).

However, there is a broad consensus on the need to integrate and manage design activities in the innovation processes – as soon as a mere „need“ is identified even before the idea is formulated (de Mozota, 2003). Design is an important part of innovation processes and it is therefore integrated into the major process models (Herstatt and Verworn, 2007, Gaubinger, 2009) which clearly describe the activities and responsibilities of design at any stage of the innovation process (Gaubinger, 2009).

But as general conditions, such as globalized product development, shortages of raw material resources and lifestyles, are significantly changing (Friedman, 2008), the detailed analyses of all the influences between design, its implementation in innovation processes and sustainable development become more and more necessary. The knowledge of these interdependencies is of vital importance for the development of products which are not only environmentally more sustainable but also of greater economic and social benefit in the long range. More than ever responsible design is not just targeted towards a minimal negative impact on the environment, but also towards the general impact on all dimensions of sustainable development. It is becoming more and more accepted that design is of vital importance for creating more sustainable product life cycles and sustainable innovations, and that sustainability has to be integrated into all phases of the innovation processes (Vezzoli and Manzini, 2008).

Since the sustainability and the environmental impacts of products are usually determined in the defining early stages of the innovation process, decisions in design have a significant effect on sustainable development. But if design – beside its traditional tasks – is more and more about the sustainability of products, then the task of designers cannot solely be, anymore, the definition of the

aesthetic or production-related qualities of products (Fuad-Luke, 2009). The problem in this respect is, that designers usually are neither educated for these emerging tasks, nor are they tapping the traditional implementation of design activities in innovation processes for the full potential of design for sustainable development. It is evident, that the design as a discipline has to adapt to the emerging changes and challenges (Esslinger, 2011, Shedroff 2009). Therefore a better understanding of the potential of design to foster sustainable development is necessary - beyond the methodical improvement of EcoDesign which is based on content and methods of traditional product development processes (Tischner and Schmincke, 2000, Wimmer et al. 2011).

Hence, there is an increasing need to research the impact of design and design-decisions on all phases of a product life cycle, on our product culture and on sustainable development in general. This knowledge is needed to develop appropriate strategies and tools for the successful integration of sustainable design into design education and innovation management. This article aims to make a contribution in this direction.

### Research questions

Based on the recognition that sustainability is a requirement for successful economic activity, the first question is which success factors mostly influence the sustainability of a product: What are the most important parameters within the product life cycle that make a product sustainable? In addition to technology-centered aspects this survey focusses on the holistic view of economic, environmental and social aspects of sustainability, that are capable of being influenced by design-decisions.

The second question focusses on the necessary conceptual and operational changes in the field of product design itself in order to foster these factors and to achieve sustainability in the long range: How can the field of design make a maximum contribution to sustainable development? The answer to this question is a challenge for the discipline of product design, for design education and also for the management of innovations.

### Research design

To answer the research questions, beside a comprehensive literature research to narrow down the search field, an empirical primary study was conducted. The aim was to gain access to the mindsets and feelings of experts – and thereby provide indications of the most important parameters for sustainable product design. The chosen qualitative and semi-structured approach allowed the experts to express ideas and experiences straightforwardly, thus delivering a deeper insight into what they really “feel and think“ that is important for establishing truly sustainable artefacts.

As part of the primary study, 23 qualitative interviews with experts<sup>1</sup> were conducted.

The expertise of the interviewees corresponded to consumer and investment goods (based on the MIGS classification of the European Union; EU 2007). To leave as little as possible potential parameters unconsidered the expert's knowledge referred to all phases of a product life cycle<sup>2</sup>. In addition, experts in the fields of climate change, science, society and consumption were interviewed.

The interviews with the experts were designed as semi-structured interviews and were translated into individual cognitive maps - visual representations of the cognitive structures of the respective expert. The experts were asked about which factors within the life cycle of products he/she thought would have the greatest impact on sustainable development. From the expert's concepts (mental representations; mostly short phrases) as well as from their mental connections a cognitive map emerged in the course of each interview and was subsequently transmitted to the data analysis

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<sup>1</sup> According to Meuser and Nagel (Meuser and Nagel 2009) an expert is somebody who is in some way responsible for the design, development, implementation and/or control of a problem-solving; and therefore, has privileged access to information about groups of people, social situations, decision-making processes, policies and so on.

<sup>2</sup> The product life cycle concept was therefore defined as the sequence of all phases in the course of a product's life - from the initial idea for a new product to its disposal (referring to the integrated product and technology life cycle concept of Pfeiffer and Bischof; Pfeiffer et al., 1997).

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software *Decision Explorer*, with which a central analysis<sup>3</sup> was carried out to identify the success factors and their importance.

The top-ten- concepts (n=220) and the core-concepts (n=22) of each individual map were detected in this manner. They were used to initially create relevant categories (the expert's „mental world“) using cluster analysis. The categories can be seen in Figure 1 in condensed form.

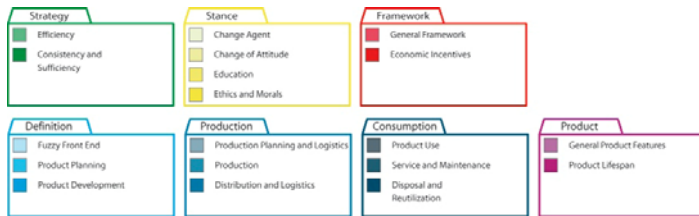


Figure 1: The categories created by clustering the top-ten-concepts

By mapping the 22 core-concepts to the categories, the influence of the respective categories on the target concept (sustainable development) was detected (for example six core concepts originated from the category „Definition“ and its sub-categories, which makes it the most influential one in the eyes of the interviewed experts.) The influence of the respective categories on sustainable development in descending order: Definition (27,3%), Strategy, Production, Consumption, Stance, Product (9,1%). The allocation of the core-concepts can be seen in Figure 2.

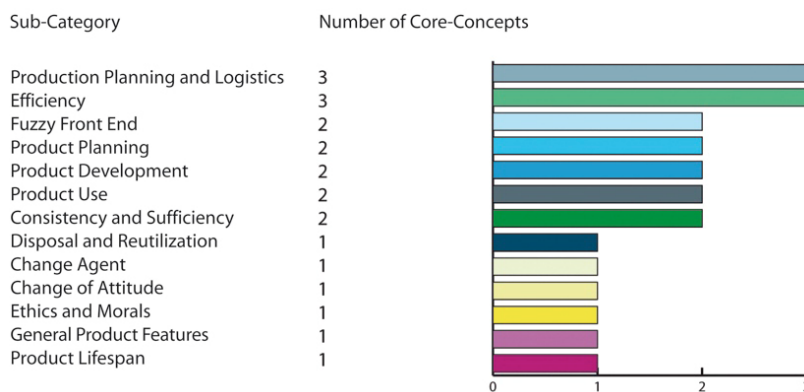


Figure 2: The allocation of the core-concepts

Furthermore, eight (product-) design-experts were interviewed to find out the need for action in the field of design regarding sustainable development. Semi-structured interviews and an online survey were made. The interviews focussed on tangible ideas of design-experts to foster sustainable development, whereas the online survey focussed on the current real influence of design on sustainable development.

From the interviews with the design-experts a total of 125 briefly recorded mental concepts emerged. The concepts were mapped to the respective categories and sub-categories from the qualitative interviews with the experts. In total 196 correlations were found between the mental concepts of the design-experts and the respective sub-categories of the experts. The more mental concepts referred to a certain (sub-)category, the more associations the design-experts had with what is essentially necessary within that (sub-)category to achieve sustainable development (see Figure 3).

<sup>3</sup> A central analysis in *Decision Explorer* looks beyond the direct links of a concept and examines the complexity of links at a number of levels away from the center. So the central or core concepts that are most influential can be detected.



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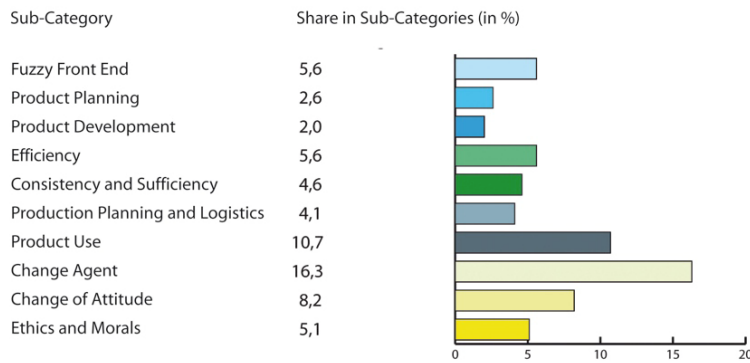


Figure 3: Share of mental concepts in the ten most influential sub-categories

As part of the online questionnaire the design-experts were also asked to answer the following question for each sub-category from the interviews with the experts: "How high do you think the current influence of product design is regarding the following problem areas?" (with values from 1/no influence to 10/very high influence). The results can be seen in Figure 4.

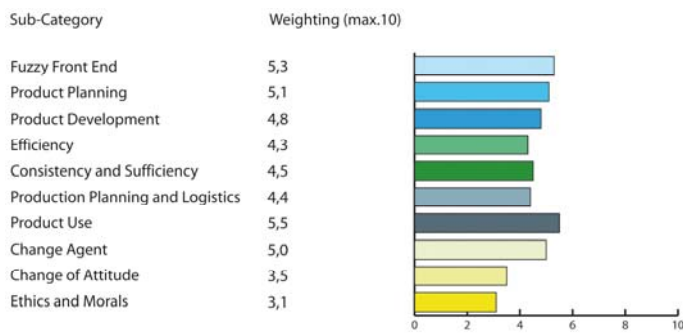


Figure 4: The current influence of design on sustainable development

## Findings

The qualitative analysis of the expert's interviews is highlighting the influence of particular parameters on sustainable development. From the expert's point of view, the two most influential ones are:

- The "Definition" of a product (from the stimuli for innovation to the decision for production)
- The creative "Strategy" in primary efficiency and also consistency "Production Planning and Logistics" (selection, production and transport of materials and intermediate goods for the production – these are substantially the phases at the beginning of a traditional supply chain)

Hence, the findings are illustrating the particular importance of creative strategies in "Efficiency" and the high impact of sustainable supply chains for achieving sustainable development. The whole defining process of a product is also of vital importance for the sustainability of products.

By contrast, the guiding values of companies (and consumers) are parameters, in which the design-experts see the most need for action (see Figure 3): The category "Stance" is the most important category by far as determined by the values of its respective sub-categories for the interviewed design-experts. This category is strongly affected by ethics and moral commitment. Moreover, two of the three most influential sub-categories for the interviewed design-experts are also part of the category "Stance" (see Figure 3):

- "Change Agent" (changing the guiding values of companies and strengthening their Corporate Social Responsibility)
- "Product Use"
- "Change of Attitude" (changing the guiding values of consumers)

With the design-experts' emphasis on the guiding values of companies and consumers (category "Stance") in mind, it is obvious that the interviewees do not see the need for action in parameters such as "Efficiency" and "Production Planning and Logistics", which are the most influential ones for the experts.

### Conclusions

The survey as well as the literature research provide an indication that, in the eyes of the experts, sustainable development is essentially a matter of efficiency and planning. The design-expert's point of view, however, is strongly affected by ethics, moral responsibility and the focus on user needs – and therefore based on a different mental concept on how to achieve sustainable development and develop sustainable products. It is obvious that designers tend to raise an ethical claim - but it seems design as a discipline has by far not enough influence and competence to meet that claim.

However, the survey points to key success factors for the sustainability of products - such as highly sustainable supply networks, creative strategies or the guiding values of companies and consumers - that are often neglected in innovation processes, but are already important success factors for companies (Carbonaro, 2008). Designers are usually neither educated or professionally trained within these areas, nor do they have a high influence on them. Beyond the design and the development of products that are highly efficient in terms of resource and material efficiency, these success factors for sustainability, that design as a discipline must assume more responsibility for, must be seen in:

- The creation of really sustainable supply networks and that of the entire "hidden history" of products as influenced by design: It seems reasonable to assume that there is too little understanding of these mainly technical and economic issues in the field of design. Moreover, "Production Planning and Logistics" and "Efficiency" are objective and not very emotional issues that do not originate in the basically human-centered approach that is deeply rooted in design-history. Design for sustainable solutions must focus on designing the entire supply networks that products originate from (designing the "hidden history" of products).
- The designers' moral claim: It must be used for acting as change agents for sustainable development. The designers seem to be aware of their responsibility for the product culture and the importance of a clear ethical position to foster sustainable development. Nevertheless, they are not able to use this moral claim and act as change agents for sustainable development. This is especially true for the very highly rated need for action with respect to the guiding values of companies. Design for sustainable solutions must focus on raising *and enforcing* an ethical claim (acting as change agents for sustainable development).
- "Product Definition" and customer awareness as core-competences of designers: The study shows the importance of the entire definition phase of products as a factor of success for sustainable development. The results show the high influence of design-decisions on the definition of a product and on the use of products and the entire category "Definition" is the one that design currently has the highest impact on. As for the category "Product Use", both influence and need for action are rated comparatively high by the interviewed design-experts. Despite always focusing on customer awareness, the designers seem to be obviously aware of need for action in this category if sustainable development is the goal. Design for sustainable solutions must – once again - focus on the "Definition" of products and on the needs of people (designing the cultural relevance of products).

### Practical Implications and Prospects

It goes without saying that the results of this qualitative study solely provide clues and emphasize the need for further research. Nevertheless, the study is highlighting the most important factors of success for sustainable products and recommends procedures for the field of sustainable design. And thus provides important clues to the future of design and an innovative design education.

With the results of the study in mind, it is evident that the professional skills of designers have to be adapted to the challenges that emerge from a non-sustainable product culture: Today's design, with its still basically esthetic, artisan nature, is increasingly helpless and without influence in the face of the complex global problems, since designers, owing to their education, are usually only inadequately

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qualified (Baur and Erlhoff, 2007, Papanek, 2009) and frequently may even be only slightly motivated to foster sustainable development (the interviews showed that as well).

Today, the initial situation is very similar to what it was around the Mid-19th century in Germany, when it was recognized that experts with radically new qualifications must be educated for an emerging technical industrial age. The result was colleges of technology as a reaction to the increasing industrialization in Germany. Today, for a beginning era of sustainability, we also must qualify many people comprehensively and quickly – especially the creative ones responsible for our product culture, but until now we have wantonly neglected – and are continuing to neglect – to provide reasonable education for the massive global challenges of a non-sustainable product culture. And what we lack are less the technical and scientific skills. Instead we lack cultural, creative skills in solving problems. Designers, owing to their education and predisposition, usually have the cultural-creative potential, the capacity for network thinking and for developing holistic solutions, which go far beyond esthetic, artistic questions. Designers are also much better qualified than any other professionals to solve complex problems (Cross, 2007) and deliver creative approaches “off the reel”. These skills of design, applied to develop a truly sustainable product culture – and not only to the continued design of mass-produced goods – procure high added value for society and companies in the long range, open up future prospects for design itself and permit the motivation for sustainable solutions *by design*.

With the results of the study in mind, it is obvious that the discipline of design must react extensively and rapidly to both content and concept. Beyond the training of artistic and manual skills, and beyond teaching technology-driven aspects of our product culture, the education of design for future generations of designers must urgently focus on the most important factors of success as described above. Design education must help shape thoughtful and creative leaders for sustainable development within the man-made environment. Because rather than a noticeably meritless creative service, design is a fundamental strategic discipline with far-reaching consequences for the entire life cycle of a product - and beyond that for our entire product culture.

For this reason, a new generation of designers will be of essential importance economically, ecologically and socially for all of our future.

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## Resources, Innovation and Lifestyles

Michael Kuhndt

Head

CSCP

Germany

### Abstract

Average lifestyles in most of the western world exceed sustainable levels by a factor of three to five (Global Footprint Network, 2009). The biggest impacts amongst Europeans fall into the categories of food, mobility and housing (EEA, 2010). Our lifestyle choices are also adversely affecting our health and well-being (WHO, 2010).

Consumption patterns of individuals linked to their choice of lifestyles differ around the world but also from household to household. Enabling and encouraging more sustainable lifestyle models requires a deeper understanding of differing lifestyle needs and desires to be met, and the differing motivators, influencers and triggers to behaviour change. Individual lifestyle choices can be shaped by national policies, cultural norms, availability of resources, goods and services, but also by personal desires and societal trends. Behaviour change can be dependent on a person's sense of urgency and in today's society increasingly driven by one's need for instant gratification, or one's ability to delay it.

Alternative, and less impactful, models of living are also emerging. Examples of promising practice have been scattered, but they do exist and their numbers are growing. Taken together these examples provide us with a picture of what more sustainable living practices could look like. Forecast into the future, these alternative living models become *sign-posts* to possible futures where current lifestyle impacts have been overcome.

The SPREAD Sustainable Lifestyles 2050 Social Platform Project, funded by the European Commission's Seventh Framework Programme: Socio-economic Sciences and Humanities, has been exploring the key challenges to more sustainable living in Europe, and has created scenarios for more sustainable living in 2050.

## Resource Efficient Europe

Dr Harry Lehmann

General Director

Division – Environmental Planning & Sustainability Strategies

Federal Environmental Agency (UBA)

Germany

Natural resources are the material, energetic and physical basis of life. Our prosperity is based not only on minerals, fossil fuels or biomass as other natural resources, like biodiversity, the environmental media of water, soil and air, flow resources (wind, geothermal, solar, tidal energy) and surface area are also important factors for our economies. They serve to satisfy our needs, as energy sources, habitat, sinks for our emissions, recreational space, pools of active pharmaceutical ingredients and much more. Annually, we extract, process, and reap nearly 70 billion tonnes of raw materials worldwide from our environment. Ultimately, all forms of resource utilisation across the entire value chain – extraction and processing of raw materials or use of the resulting products – impact other natural resources. Pollutants in soil, water and air and surface sealing exert pressures on the environment. They negatively affect the sustainability of ecosystem services, natural biocoenosis and human health. Natural resources are limited and are often not available in high quality. The global population and economic growth increases the pressure on natural resources and may cause competition for use.

Resource conservation examines materials management extended over product lifecycles and looks for ways to reduce resource utilisation and associated environmental impacts. Already today, and not only in terms of resource utilisation, non-sustainable forms of growth and development in industrialised countries have put the world on a collision course with fundamental planetary boundaries, especially at the expense of the developing countries. If the production and consumption patterns of the industrialised world were to be adopted by nine billion people in the future, planetary boundaries would be far exceeded, with catastrophic consequences. The problems are escalating, and because the global consumption of resources continues to rise almost unabated, there is a growing need to solve them.

This involves the following:

- Reducing environmental problems caused by the excessive consumption of resources and which overly burden water, soil and air sinks.
- Avoiding social problems associated with resource processing and utilisation.
- Avoiding or limiting resource depletion, because access and distribution of resources can also trigger or cause resource conflicts.
- Reducing dependency on imports and their associated economic and political consequences.
- Minimising negative economic and social effects that result from global price increases and fluctuations in commodity prices.
- Reducing waste and increasing recycling.
- More equitable distribution both between the regions of the world and between generations.

Increasingly, the question is discussed to what extent wealth can be secured through less, structurally altered, or without growth, and thus with less negative environmental impact. Some limitations of material growth have already been exceeded today - particularly in regard to the capacity of environmental media to absorb contaminants, but also for some raw materials such as conventional oil. In economic terms, natural capital is scarce. In relation to global economic growth and the rising demand of the world population, it will undoubtedly become even scarcer.

## **Sustainable LivingLabs – European Research Infrastructure For The User-Integrated Development Of Sustainable Product And Service Innovation (SusLabNWE)**

Dr. Christa Liedtke

Director of Research Group “Sustainable Production and Consumption”

Wuppertal Institute for Climate, Environment, Energy

Doeppersberg 19

42106 Wuppertal

Germany

Carolin Baedeker

Co-Director of Research Group “Sustainable Production and Consumption”

Wuppertal Institute for Climate, Environment, Energy

Doeppersberg 19

42106 Wuppertal

Germany

Holger Rohn, Project Co-ordinator

Wuppertal Institute for Climate, Environment, Energy

Doeppersberg 19

42106 Wuppertal

Germany

Marco Hasselkuß, Junior Research Fellow

Wuppertal Institute for Climate, Environment, Energy

Doeppersberg 19

42106 Wuppertal

Germany

Professor Dr. Viktor Grinewitschus, Professor for Building Services

Hochschule Ruhr West, University of Applied Sciences

Institute for Energy Systems and Energy Business

Campus Bottrop

Tannenstraße 43, 46240 Bottrop

Germany

### **1. Introduction**

Due to its high demand of resources and energy, housing is – next to food and mobility – generally considered one of the key areas in need of sustainable transitions (i.e. Acosta Fernández 2011;

Druckman et al. 2011). Domestic sustainable product or service innovations are expected to play a key role in this transition process. Society's welfare generation has to happen within the natural system's boundaries (Liedtke et al. 2012a; Lettenmeier et al. 2012; Mancini et al. 2011).

Experiences with potentially sustainable product-service-innovations (e.g. new models of supply, CarSharing, new lighting systems or "just" less energy-consuming water boilers) show that these developments often do not perform in the intended way – either because of low user acceptance or because they show negative rebound effects. Rebound effects can decrease or even overcompensate for i.e. energy savings due to an increase in demand for the same good or because they enlarge consumers' budget to spend on other resource inefficient activities and should carefully be accounted for (Madlener 2012; Thomas 2012; Santarius 2012). Another important determinant for rebound effects is unexpected user behaviour or wrong application of potentially sustainable innovations (Liedtke et al. 2012a). Sustainability innovations should, therefore, embrace both technologically efficient developments and social innovation in the sense of inducing new sustainable social practices.

The paper focuses on this aspect and introduces the Sustainable LivingLab (SLL) research infrastructure to design interactive value chains. Through the design of such interactive value chains (Schelske 2008; Walther 2010; Reichwald and Piller 2006) – meaning to integrate users and other stakeholders along value chains into product-service-development – we hypothesise that developments have a higher chance of successful diffusion. By integrating the user as the most relevant expert (and cause of rebound effects) in the innovation process, SLL aims to reduce negative rebounds.

The paper is subdivided into five chapters. In chapter two we briefly discuss the theoretical conceptualisation of SLL. In chapter three we introduce the research lines of SLL and how currently a European research infrastructure is set up in the SusLabNWE project<sup>1</sup>. Furthermore, the Three-Phases model of research for SLL and its methodological application in the German focus region InnovationCity Ruhr is discussed, where a pilot focusing on heating and space heating will be developed. Studies show that approximately 80% of all heating systems in Germany work inefficiently, however the major impact of energy consumption is induced by user behaviour. Combined with optimising user behaviour, savings of 10-30% of heating energy are possible (Messerschmidt 2012). In the last chapter, we resume the potentials of SLL and draw a conclusion with regard to sustainability innovations and lifestyles.

## 2. Theoretical Approaches to conceptualise Sustainable LivingLab

The Sustainable LivingLab (SLL) approach integrates recent advancement in research strands like consumption research, innovation, sustainability and transition research (detailed description in Liedtke et al. 2012b).

**Innovation research** shows that innovation processes are currently opened up, integrating stakeholders, other businesses and end-users into product-service-development. Concepts like "Open Innovation" (Chesbrough 2003), "Wisdom of Crowds" (Surowiecki 2004) or the "Lead-user"-concept (von Hippel 1986) as well as the design of transformational products (Laschke et al. 2011) reflect this. Additionally, we draw on **systemic innovation** and social studies of technological development. Regarding the "co-evolution" of innovation trajectories (Rip and Kemp 1998), it can be concluded that sustainability innovations can only be developed in an experimental and interactive setting (Co-Design). E.g. Diehl (2011) describes methods for user integration in domestic sustainability innovations.

To involve users into research, the approach can also draw on the methodology of **action research** (Lewin et al. 1953), assuming that scientific advancement can only be achieved if professional researchers actively involve 'laymen' into their research, in order to try and intervene in existing social structures. For the SLL approach, the breadth of user involvement can be adapted flexibly, integrating users and stakeholders at all or at specific stages of research, i.e. in the phases of *defining a problem*, *designing a research strategy*, *creating results* or *application of results* (Talwar et al. 2011).

Studies have shown that the benefits of eco-designed innovations are hardly realised if designed without reference to user practices (Spaargaren 2011). Therefore, SLL refers to **Social Practice Theories** to conceptualise environmental behaviour and consumption (Bourdieu 1977; Giddens 1984;

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<sup>1</sup> For more information see: [http://www.nweurope.eu/index.php?act=project\\_detail&id=4203](http://www.nweurope.eu/index.php?act=project_detail&id=4203)



Reckwitz 2002; Warde 2005; Røpke 2009; Jackson 2005). Social practices refer to a – largely routinized and widespread – type of behaviour in everyday life (i.e. showering, driving to work). New technologies may trigger new demands, understanding that rather practices than individual desires create wants (Warde 2005). To disturb and change routine practices, i.e. **transformational products** appear promising (Heidecker et al. 2010, Hassenzahl et al. 2011).

To account for sustainability potentials and to early identify possible rebound effects along the entire value chain, SLL can build on several findings from **Sustainability research**, which has developed tools and methods for sustainability assessments (see e.g. de Ridder, 2005; Clark et. al. 2004; Baedeker et al. 2005; Klöpffer and Renner 2007; Geibler et al. 2010) and the MIPS method (Mancini et al. 2011; Liedtke et al. 2010).

**Transition** can in terms of Practice Theory be seen as a circumscribed process or trajectories of change, within the time-space bound reproduction of social practices (Spaargaren et al. 2006). Transition research studies complex socio-technical change processes to meet challenges of sustainable development (Geels and Schot 2007). To describe complex change processes the Circular Transition Model was developed, which distinguishes the phases of Problem Assessment, Vision Development, Experiments and Learning & Upscaling (Loorbach 2010). At the Wuppertal Institute transition research is established as a meta-approach for sustainability research (Schneidewind et al. 2011). The phases of Experiments and Learning & Upscaling can especially well be conducted within the SLL infrastructure.

### 3. The methodology of Sustainable LivingLabs (SLL)

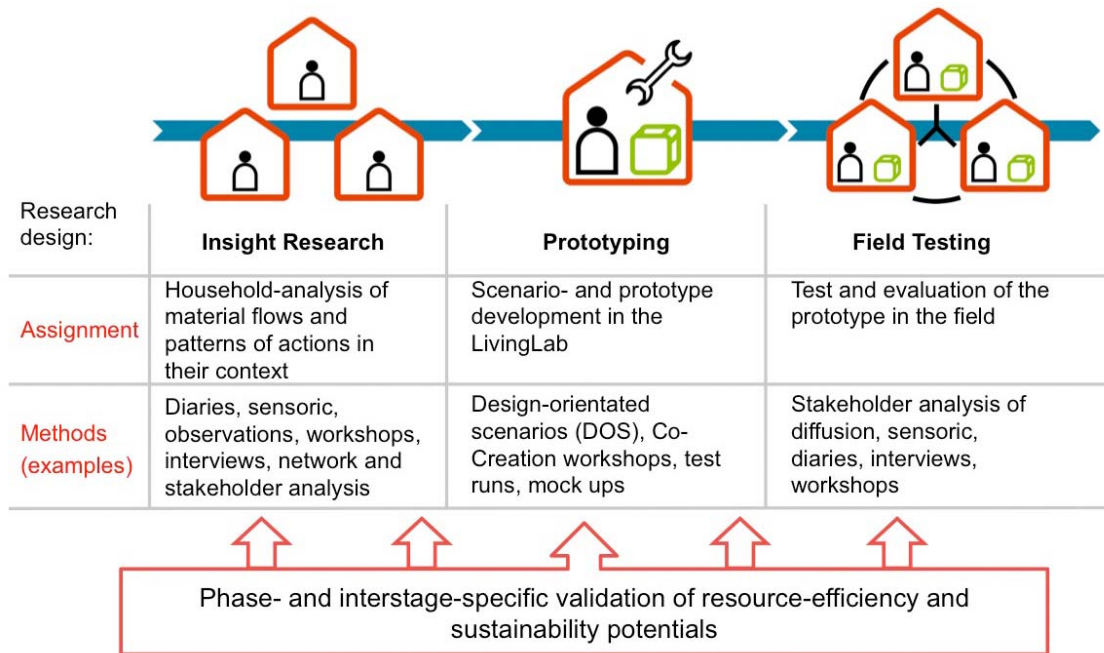
In an initial European LivingLab design study<sup>2</sup>, five main Research lines and a methodological Three-Phases model were developed (Welfens et al. 2010). The research lines cover: *design, construction and maintenance of sustainable homes, integrated approaches to home energy management, the connected home, resource-efficient lifestyles and social networks and new product and service development*. Results showed that, “products with significant environmental effects in the use phase should be developed in LivingLab with a clear focus on the user context to prevent unwanted side effects” (Liedtke et al. 2012a: 12).

Building on this, the Wuppertal Institute advanced an extended LivingLab research methodology, focussing on sustainability innovations and considering entire value chains (SLL; see figure 1).

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<sup>2</sup> This design study was conducted within the 7th Framework Programme of the European Union (2008-2010) in a cooperative project by four academic (led by TU Delft in cooperation with ETH Zurich, Universidad Politecnica de Madrid, Wuppertal Institute) and three industrial partners (ACCIONA, BASF, Procter & Gamble).

Figure 5: The Three-Phases Model of Research for SLL and examples for methods used in SusLabNRW



In the first phase of “Insight Research” the existing status quo in a field of interest is explored and the required level of change is analysed in the real-life environment of actual households. Figure 1 shows different methods that can be employed in order to do so. During the second phase of “Prototyping” the user-integrated development of actual product-service- innovations is conducted and prototypes are tested in LivingLab facilities. In the last phase “Field Testing” developments are evaluated and redesigned if necessary. Distinctive feature of the SLL methodology is the phase- and interstage-specific validation of resource efficiency and sustainability potentials of the new prototype.

In the next section, we introduce the application of this methodology in the ongoing European research project SusLabNWE, conducted by TU Delft.

#### 4. Application of the Sustainable LivingLab-infrastructure: The SusLabNWE-project with special focus on the German SusLabNRW model region

The SusLabNWE project, funded by the European Regional Development Fund (ERDF), Programme INTERREG IVB NWE, aims to set up a European infrastructure of LivingLab test facilities at different locations, which co-operate in user-centred development of sustainability innovations around the home (see figure 2).

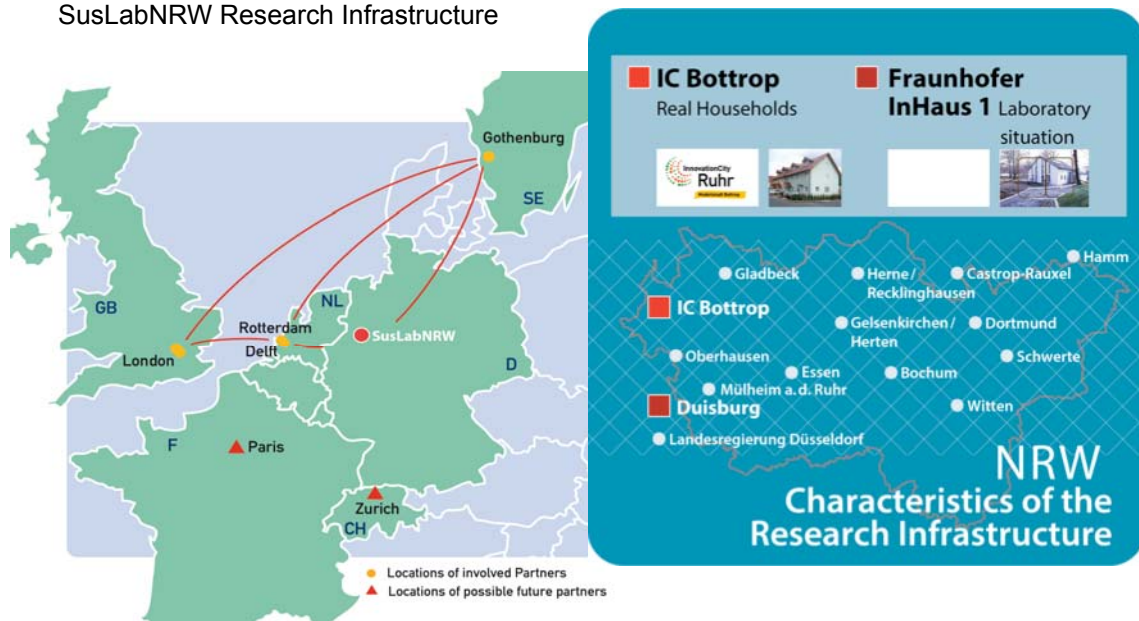
The focus area of the German consortium (Wuppertal Institute, Hochschule Ruhr West and InnovationCity Management GmbH) is located in the Ruhr area in North Rhine-Westphalia. Here, the model region ‘InnovationCity Ruhr, Model Town Bottrop’<sup>3</sup> is involved in SusLabNWE as the regional SusLabNRW sub-project<sup>4</sup>, which is co-financed by the Ministry of Innovation, Science and Research of the German Federal State North Rhine-Westphalia.

<sup>3</sup> The idea of InnovationCity Ruhr, Model Town Bottrop, is to transform a complete city district with a population of about 70,000 into an exemplary district for energy efficiency by 2020. More than 100 projects addressing different fields of action have already been proposed - some are already implemented. InnovationCity Ruhr is managed by the InnovationCity Management GmbH which is an official partner of SusLabNRW (for more information see <http://www.bottrop.de/microsite/ic/>)

<sup>4</sup> For more information on the German sub-project see [http://www.wupperinst.org/projekte/proj/index.html?projekt\\_id=426&bid=29](http://www.wupperinst.org/projekte/proj/index.html?projekt_id=426&bid=29)

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Figure 6: The SusLabNWE consortium and the German SusLabNRW Research Infrastructure



The Sustainable LivingLab (SLL) infrastructure provides means to observe social practices, involving technical artefacts in the process of everyday use, both in real households (IC Bottrop) and in a LivingLab test facility (Fraunhofer inHaus). Additionally, a LivingLab-Container at Hochschule Ruhr-West is employed to test prototypes. Taking social practices of using the new product into account is key to successful innovations, since all too often products designed for environmental efficiency under given circumstances are misused, resulting in unintended less sustainable outcomes (Liedtke et al. 2012a).

The German consortium addresses the main research question of *how energy and resource efficiency in buildings can be increased through the integration of users and actors along the entire value chain of heating and space heating into the development of sustainable processes, services or products*. Expected outcomes include scientific findings on user-integrated product-service-innovations in the field of energy provision, enhancements of methods for integrating stakeholders into such innovation processes and the compilation of qualification material for actors along the value chain (i.e. for handicraft). Furthermore, a mock-up for a product and services along the value chain of heating and space heating will be developed, employing methods of user integration.

Several scientific and business partners co-operate in the SusLabNRW sub-project. The following figure 3 shows the current project partners and potential stakeholders for installing a future SLL infrastructure. Business partners will be involved at different stages of the Three-Phases model of research, depending on their field of interest and involvement in the value chain of heating/space heating. The aim is to establish a permanent SLL infrastructure including science, business, politics and real households to employ in other relevant fields in the future (i.e. sustainable mobility, food).

Figure 7: Stakeholder-Map of SusLabNRW



All activities in the SusLabNRW project are conceptualised and conducted according to the Three-Phases model of research (compare figure 1). Current activities mainly concentrate on the conceptualisation of Insight Research and a pre-analysis of building characteristics in Bottrop, Model Town of InnovationCity Ruhr was performed, based on data from housing societies and InnovationCity Management GmbH.

Studies show that 10 to 30 % of a household's energy consumption can be saved by combining efficient set-ups and optimising user behaviour (Messerschmidt 2012). First results from the pre-analysis – conducted by Hochschule Ruhr-West – of energy consulting in InnovationCity and of data from the housing society Vivawest show that energy consumption in older buildings is more efficient than generally assumed and in new buildings it is not automatically better. That shows that significant differences in energy and heating consumption do not result from different building infrastructures alone. Much more, these results support the assumption that user behaviour has a great impact on heating energy consumption.

### First Phase: Insight Research

Point of departure is an in-depth analysis of households in IC Ruhr. This phase is sub-divided into several steps, accounting for material flows/energy consumption and researching patterns of action.

- 1) Broad-based qualitative interviews will be conducted with households in the target area in IC, coupled with energy consulting services of the Centre for Information and Consulting (ZIB) and area-wide door-to-door consulting. The focus is on energy consumption, heating behaviour and the cost structure of heating.
- 2) Hochschule Ruhr West will perform an analysis of heating data through a pre-analysis of building characteristics based on data and data collection of heating behaviour in 24 selected households. Data loggers will be installed in three rooms each to measure room temperature, air quality, humidity for a period of 14 days.
- 3) The Wuppertal Institute will conduct a MIPS-analysis<sup>5</sup> (material footprint) in about 12 selected households concerning the key areas of housing, mobility and food. The aim is to analyse

<sup>5</sup> MIPS allows to estimate the environmental impacts caused by a product or service, considering the whole life-cycle from cradle to cradle, by dividing material input (MI) by the service unit:  $MIPS = MI \text{ (kg)} / \text{Service unit}$ . MI covers all natural resources taken out of nature and transferred into technosphere. Accordingly, all new natural resources used for functioning of the technosphere including the different value chains and the using phase will be considered (Schmidt-Bleek 1994; Schmidt-Bleek et al., 1998; Ritthoff et al. 2002). In addition to assessing products, services, companies, regions and nations ecological backpack the MIPS concept has already successfully been applied to analyze household consumption (Kotakorpi et al. 2008).

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resource intensity in these different areas through diaries and observations regarding user behaviour and expenditure patterns.

- 4) Additionally, a social network- and stakeholder- analysis will be conducted. Thus, e.g. the centrality of actors or the strength of relations within a social network can be measured, allowing to identify actors in a position to easily spread information. Opinion leaders and (non-) lead users in the personal networks of actors can be found, who are believed to have influence on heating behaviour.

To exemplify the operational plan in SusLabNRW, scheduled steps for the data collection of heating behaviour in selected households within the Insight Research are described in the following.

### **Operational plan: heating behaviour in selected households**

An analysis of the overall potential to increase energy efficiency for different measures taken is performed and data monitoring is prepared.

#### 1. Selection of apartments for monitoring of user behaviour

- Selecting test persons for monitoring of user behaviour in cooperation with the project's business partner Vivawest (housing society) and other partners.
- Defining the kind and structure of data to be collected in cooperation with other European LL locations. A procedure for data analysis will be derived: how to interpret data in terms of which level of comfort (regarding room temperature, air quality, humidity) was aspired and which one was achieved with how much energy input? Which potentials to increase efficiency become visible?
- Defining a concept to measure local weather conditions (outside air temperature, sunshine hours, air humidity, wind speed)
- Application of data loggers and monitoring boxes in apartments, including briefing of inhabitants and developing a declaration of consent.
- A data analysis of chosen households in the LivingLab area focusing on housing / construction can provide insights into underlying material flows and related lifestyles. The resource- and efficiency potentials are evaluated phase and interstage specifically. Target fields are topics with a high sustainability impact: housing, food, mobility and related supporting technologies e.g. ICT- Products and Services and services e.g. canteens, car sharing, facility management.

#### 2. Analysis of buildings' energy efficiency:

- Analysing energy efficiency of buildings (thermal bridges, insulation, windows) and of heating systems and their performance (age, operating time of aggregates, hydraulics, degree of efficiency)
- Developing an energy pass for both the demand and usage of analysed buildings
- Analysis of potentials to increase energy efficiency through adjustments or investment measures

### **Second Phase: Prototyping**

In this phase, the identified weaknesses in the system and value chain (producers – handicraft – users – consultants) are outlined and tailor-made service offerings will be developed. Service offerings will be developed in e.g. co-creation workshops, integrating users, producers and designers.

Alongside, assistance functions that support users to increase energy efficiency will be developed, based on collected data like time profiles for room temperature or information on room airing. The mock-ups are planned to be set-up in Fraunhofer inHaus and in the LivingLab-Container, representing a LivingLab surrounding. Here, they will be tested by users, providing them with explanations and information on necessary changes of interior equipment.

Steps to develop an infrastructure for assisted living in the flats include:

- Definition of assistance functions in flats, developing and testing a prototype in the LivingLab
- Definition of diagnostic functions for systems engineering

- Definition of methods to classify the building envelope
- Tests to analyse energy consumption with and without activated assistance functions in the LivingLab
- Analysis of energetic effects of assistance functions
- Comparison of results with those of other LivingLabs
- Development of a concept to implement assistance functions into the existing infrastructure of buildings.

### Third Phase: Field Testing

Conducting the third phase of evaluating the prototype in the field, based on similar methods as employed in the first phase, is currently not planned within the scope of SusLabNRW.

Throughout the development process a phase- and interstage-specific validation of resource efficiency and sustainability potentials of the new prototype along value chains is performed. Thus, necessary re-adjustments can be performed at any stage of the process. However, data availability is often limited in the beginning since applications of developed products or services might only show in the future (Geibler et al. 2006). Throughout the process, time for reflection and learning is provided in the sense of learning loops.

## 5. Conclusion

The Sustainable LivingLab infrastructure can provide means to develop sustainable product-service-innovations with careful regard to actual user practices if certain barriers are overcome. These include the activation of all relevant stakeholders and avoiding technological predeterminations (see Geibler et al. 2012), thus accounting for sustainability potentials and possible rebounds throughout the development. In the course of SusLabNWE, a European research infrastructure will be established and a pilot in the field of heating/space heating will be developed at all locations. One aim is the promotion of transnational activities and supra-regional collaboration while taking regional differences and cultural diversities into account.

In the long run, a permanent SLL infrastructure in Germany and in the other involved countries should be established and used to develop sustainability innovations in further areas of relevance (i.e. mobility, food). Sustainability transitions in these fields should also be conceptualised with regard to user practices. SusLabNWE is a first important step towards this.

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# Offer Characteristics Determining Perceived Usefulness Of Environmental Communication

Marcus Linder

PhD student

Chalmers University of Technology

Vera Sandbergs allé 5, 41296

Sweden

## Abstract

A survey sent to the CEOs of very small environmentally oriented Swedish firms indicates that environmental policy support and cost saving eco-efficiency can be predictors of the perceived marketing benefits of communicating to customers credible claims of low environmental impact. High levels of environmental policy support are positively associated with the perceived usefulness of credible claims, but high levels of cost saving eco-efficiency show a negative association with the perceived usefulness of credible claims of low environmental impact.

## Introduction

Research on the determinants of successful environmental marketing for firms with offers differentiated by a low level of environmental impact is important from a societal perspective because it might promote a transition towards more sustainable industry activities. From the point of view of firms, it is even more important since many of them are still struggling to build a business case for decreased environmental impact (e.g. Blomgren, 2011).

The role of environmental impact in the marketing efforts of firms has been the object of scholarly research for several decades under the labels of ecological marketing (Fisk, 1974), environmental marketing (Coddington, 1993; Peattie, 1995), sustainable marketing (Fuller, 1999) and green marketing (Ottman, 1998; Grant, 2007). The research related to environmental marketing is diverse (Chamorro et al., 2009; Leonidou and Leonidou, 2011) and include analysis of the characteristics of green consumers (e.g. Laroche et al., 1996; Squires et al., 2001; Rowlands et al., 2003), recycling behaviour (e.g. McCarty and Shrum, 2001; Thøgersen, 2003), eco-labelling (e.g. Gallastegui, 2002) and green communication (e.g. Chan, 2000; Imkamp, 2000).

This paper focuses on green communication. Most of the existing research has studied fast-moving consumer goods, and large or medium sized firms (Leonidou and Leonidou, 2011), but we need to know more about small firms providing municipal, industrial or real estate goods and when they perceive communication of low environmental impact as beneficial for their business.

## Theory

The purpose of this paper is to estimate the impact of a set of offer characteristics on the usefulness of communicating to customers low environmental impact, or eco-communication. The hypothesized relationships are described in Model 1 (see Figure 1). I also propose a second model (Model 2) that focuses on a sub-construct of eco-communication: the perceived importance for marketing the offer of the ability to make a trustworthy claim of low environmental impact, or eco-credibility. There are four independent variables in these models: eco-efficiency; policy support; claimed eco-differentiation; and financial performance. These are depicted in Figure 1 together with their hypothesized associations (H1a-H4b).

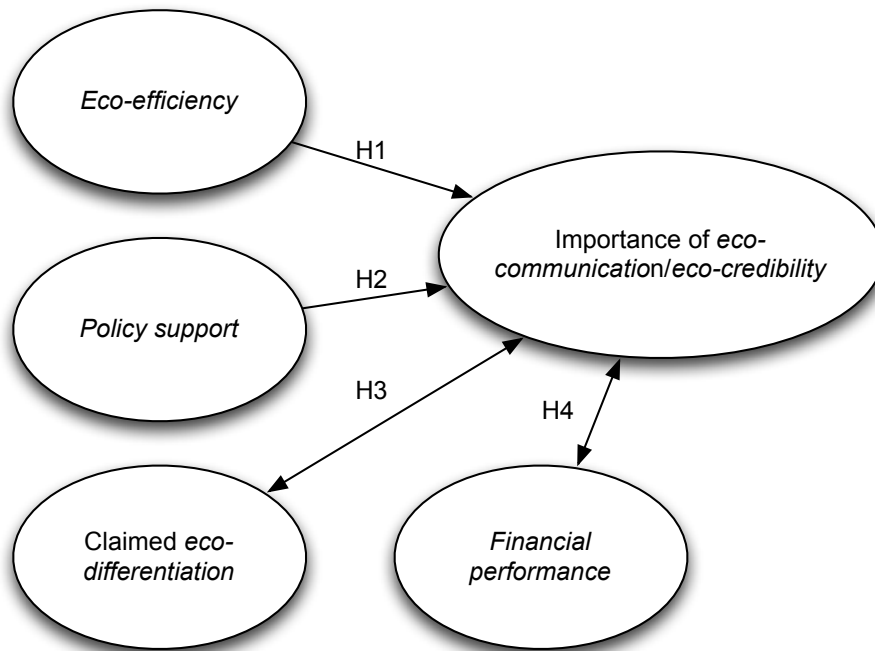


Figure 1. An illustration of the relationships examined

**Eco-communication** refers to the positive marketing effects or importance of communicating to customers low environmental impact. Firms that help their customers to signal to peers environmentally cooperative behaviour, via say eco-branding, might leverage societal norms and drive sales (Griskevicius et al., 2010). For example, even a commodity product, such as electricity, can be branded 'green' (Roe et al., 2001). However, successful cases of eco-communication relate mostly to the foods, cleaning and personal care sectors (Esty and Winston, 2006).

**Eco-credibility** is a sub construct of eco-communication and refers to the positive marketing effects of making a trustworthy claim of low environmental impact. One way to increase the credibility of environmental-branding is to use eco-labels, which might enable an increase in margins or market share (cf., Nimon and Beghin, 1999; Gallastegui, 2002). Many firms perceive eco-communication as a less than straightforward way to profit from an environmental orientation because of the risk of accusations of 'greenwashing' (e.g., Bruno and Greer, 1992), which generally results from poor eco-credibility.

**Eco-efficiency** refers to the degree to which the low environmental impact of the firm's offer is related to lower costs of ownership for customers, irrespective of pro-environmental institutions (e.g. subsidies). In the literature on environmental strategies, there are examples of environmental efficiency in arguments along the lines of 'lean is green' (e.g., Florida, 1996; Lankoski, 2000; Porter and Van der Linde, 1995). Since, by definition, eco-efficiency implies that the eco-differentiation is related to cost-saving for customers, it is expected to be *positively* associated with the usefulness of eco-communication (H1a). On the other hand, there is no obvious reason to believe that these cost-savings will be associated with the importance of eco-credibility for marketing the offer (H1b).

**Policy support** refers to the degree to which the offer is supported by regulation or public policy that benefits customers. The idea of institutions to overcome problems related to common or public goods (e.g. Pacheco et al., 2010; Linder, 2012) suggests that environmentally-oriented offers could be expected sometimes to benefit from policy support or so-called hard institutions. These are sometimes encouraged by lobbying from affected firms via industry associations or similar organizations. Examples of work that deals with leveraging environmental policy include Crouse (1998), Rugman and Verbeke (2000) and Barrett (1991). Since policy support by definition implies a benefit to the customer based on the eco-differentiation of the offer, it is expected to be *positively* associated with both the importance of eco-communication (H2a) and eco-credibility (H2b).

**Eco-differentiation**<sup>1</sup> refers to the degree to which the offer has a lower environmental impact than the typical alternatives available to the customer. Because eco-communication might lead to closer inspection and possible accusations of greenwashing, the degree to which the offer creates a lower environmental impact is expected to be *positively* associated with the effects of eco-communication on marketing of the offer (H3a). In addition, eco-differentiation is expected to facilitate, that is, to be *positively* associated with eco-credibility (H3b).

**Financial performance** refers to the firm's profitability compared to expected profitability. Note, that this variable is independent on firm industry, size and age (see Appendix 1). If eco-communication benefits environmentally oriented firms, it is likely also to improve its financial performance. Conversely, if an environmentally oriented firm is financially successful, it might attribute that success to its eco-communication activities. Consequently, a *positive* association is expected between financial performance and eco-communication (H4a). The corresponding argument should apply to eco-credibility (H4b).

### Method

This paper uses ordinary least squares regression to estimate the impact of offer characteristics on the perceived usefulness of eco-communication for marketing eco-differentiated offers (Model 1). The data are from public accounts and the responses to a survey.

In addition to the initial regression (Model 1), separate regressions are run using the constituent items of eco-communication as the dependent variable. This examines any potential differences in the items due to the relatively low correlation between the two items ( $r=0.47$ ). The regression using item 1 as the dependent is inconclusive ( $F_{4,9}=1.90$ ;  $R^2=0.13$ ) and for reasons of space is not discussed further. However, the regression using item 2 as the dependent variable has considerable explanatory power ( $F_{4,9}=8.36$ ;  $R^2=0.41$ ). The variable representing item 2 is eco-credibility. Model 2 thus focuses on the perceived importance attributed to eco-credibility by the respondents. Each regression has four predictors: eco-efficiency; policy support; eco-differentiation; and financial performance.

### Sample

The study examines small environmentally oriented firms offering physical products. In this paper, I consider firms to be environmentally oriented if a) they claim that their main offer has a lower environmental impact than typical alternatives, and b) this claim is backed by inclusion in a government database of environmental technology firms. A firm is considered to be making such a claim if it answered the following item as 5 or over (out of 7): 'To use our offer creates a lower environmental impact than is the case for most alternative solutions that the customers could choose from'.

To identify active micro-sized firms in Sweden, I retrieved accounting data from Retriever Bolagsinfo in January 2012. I identified 85,073 firms based on the following criteria:<sup>2</sup>

- firms that filed an accounting report for 2010 in quarters 3 or 4 of 2011;
- limited companies (Swedish "Aktiebolag");
- firms with 2 to 49 employees (during 2010);
- excluding holding companies and firms that reported dividends from shares in other firms;
- showing profit margins between -50% and 50%

The full set of 85,073 firms was used to estimate the relative financial performance of the environmentally oriented firms in the model using a nearest neighbour matching procedure (Abadie et al., 2004).

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<sup>1</sup> Eco-differentiation is closely related to the concept of environmental orientation, but has a higher resolution. Environmental orientation is treated as a binary sampling criterion in this paper.

<sup>2</sup> The first criterion was to ensure that the studied firms had reported numbers for a similar time period. The next two criteria focused on small and micro firms (OECD, 2005: 17) and filtered out 'one-man' firms that potentially might be part-time ventures. The 4<sup>th</sup> and 5<sup>th</sup> criteria filtered out holding firms, tax minimizing or control instruments for larger economic groups, and firms that were overly investment-oriented during the analysed period. The last criterion was set after manually examining firms' accounts and exempts firms making unusual investments in the studied time period.

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To collect data on offer attributes and the perceived usefulness of eco-communication, I administered a survey to a set of firms likely to be environmentally oriented. The survey recipients were selected based on a project commissioned by the Swedish government: Swentec – Swedish Environmental Technology Council. Swentec identified a total of 901 environmental technology firms, based on Statistics Sweden’s environmental accounts and searches of industry fairs and yellow pages. Swentec evaluated each firm manually via interviews and an application form, according to whether it matched ETAP’s definition of environmental technologies:<sup>3</sup> 222 firms matched the above criteria and received the survey. The response rate was 33.3%; the majority of respondents were CEOs (86%) the rest ranged from Owner to Marketing Manager. To reduce the risk of bias in the responses due to the firm’s marketing strategy, it was emphasized that only aggregated answers would be published. An independent two-sample t-test comparing the financial performance of respondents and non-respondents revealed no response bias ( $p=0.33$ ).

Out of the 74 respondent firms, 20 did not match the intended population – typically because they did not sell a physical product (17 firms). Of the remaining 54 firms, 46 (85%) are business-to-business firms; 8 firms (15%) sell to consumers, mainly environmentally differentiated indoor climate related offers for small houses. There were no clear differences between the two groups for any of the variables. Table 1 summarizes the descriptive attributes of the sample firms. Figure 2 provides the firms’ industry classifications.

Firm attribute	Description	Mean	S.d.
Age	Years since registration	21.43	18.56
Employees	Number of employees	12.56	10.64
Turnover	Total revenue (million SEK)	34.78	40.40
Profit	Taxed profit (million SEK)	0.51	3.62

Table 1. Overview of firm age, size and profitability.

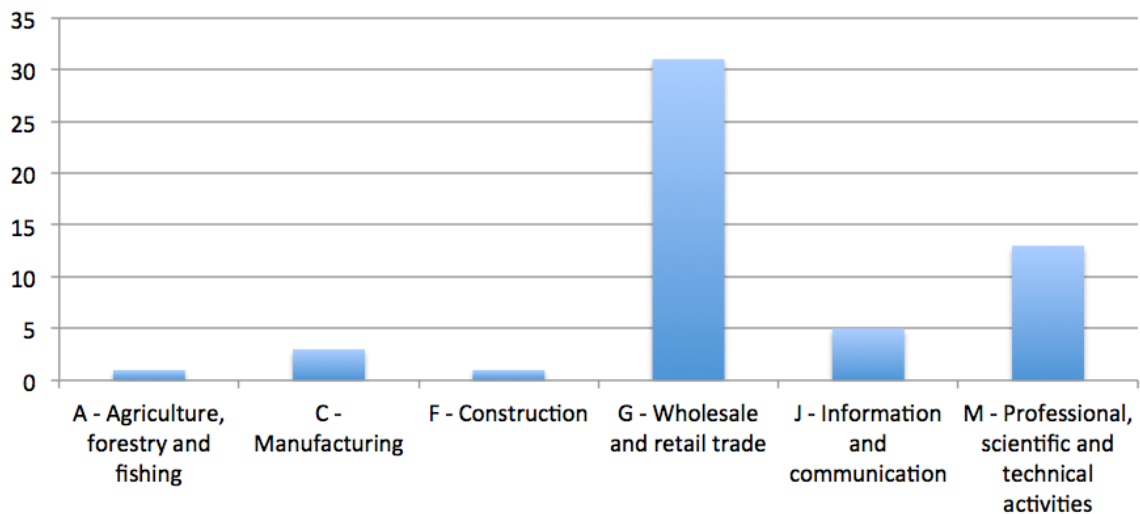


Figure 2. Industry classifications of the firms. Y-axis denotes number of firms per industry.

### The variables

Four variables were measured by the survey; two were used as dependent variables and two were used as independent variables (see Table 2). The variables were constructed by combining Likert-scale items, and treated as interval-type independent variables in the regression model (cf. Carifio and

<sup>3</sup> 'technologies whose use is less environmentally harmful than relevant alternatives [...] They encompass technologies and processes to manage pollution (e.g. air pollution control, waste management), less polluting and less resource-intensive products and services and ways to manage resources more efficiently (e.g. water supply, energy-saving technologies)' (European Commission, 2004, p. 2).

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Perla, 2007). The control variable (relative) financial performance is calculated using a nearest neighbour matching procedure (Abadie et al., 2004) based on industry classification, age, number of employees and turnover data for the full set of 85,073 firms. For details of the specific items used and the nearest neighbour procedure, see Appendix 1.

Name of variable	Description	Data source	Mean	S.d.
<i>Eco-communication</i>	Perceived importance of communicating eco-differentiation to customers for marketing the offer	Survey - 2 items	5.45	1.18
<i>Eco-credibility</i>	Perceived importance of making a trustworthy claim of low environmental impact for marketing the offer	Survey - 1 item	6.00	1.08
<i>Eco-efficiency</i>	The extent to which the offer's eco-differentiation is related to lower costs for their customers	Survey - 3 items	5.09	1.44
<i>Policy support</i>	The extent of regulatory or public policy support that the offer has at the customer level	Survey - 5 items	4.64	1.50
<i>Eco-differentiation</i>	The extent to which respondents claim that the offer creates a lower environmental impact than competing alternatives	Survey - 1 item	6.50	0.80
<i>Financial performance</i>	The profit margin of the firm minus the weighted profit margin of the firm's nearest neighbours	Accounting data	-0.02 <sup>4</sup>	0.10

Table 2. Summary of the variables.

## Results

The results in Table 3 show that the degree of policy support and claimed eco-differentiation have a significant positive effect on the perceived usefulness of eco-communication and eco-credibility for marketing the offer. In the case of the eco-credibility variable, reported degree of eco-efficiency also has a significant, but negative effect. Thus, it seems that the more the eco-efficiency of the offer helps to reduce customers' costs of ownership, the lower is the perceived importance of making a trustworthy claim of low environmental impact. The firm's financial performance is not a reliable predictor of managers' attitudes towards using claims of low environmental impact to market their offers.<sup>5</sup>

The coefficient of determination of the model examining perceived eco-communication is 25%, indicating that 75% of the variation in perceptions of the utility of eco-communication is explained by other factors, for example, details of particular offers or targeted customer segments. However, a degree of variation is explained by general factors, such as level of policy support or the claimed level of eco-differentiation of the offer. In the second model examining the emphasis on making a trustworthy claim of low environmental impact to market the offer, the coefficient of determination rises to some 41%, that is, nearly half of the variation in the emphasis put on eco-credibility is explained by the general characteristics of the offer such as eco-efficiency, policy support and claimed eco-differentiation.

<sup>4</sup> This indicates that the environmentally oriented firms in the sample, on average, have lower profit margins than their nearest neighbours in the economy. However, it is not the purpose of this paper to draw conclusions about the general profitability of environmentally oriented firms. In fact, this is done in a different paper. On this, see Linder et al, (2012), which uses several measures of environmental orientation and exploits a more elaborate method to assess this question.

<sup>5</sup> This is evident also in the correlation matrix in Appendix Table A2.1.

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	Eco-communication	Eco-credibility
	Beta	Beta
Eco-efficiency	-0.15	-0.15*
Policy support	0.26**	0.14*
Eco-differentiation	0.60***	0.76***
Financial performance	-0.55	-1.90
R <sup>2</sup>	25%	41%
F-test of model	4.03***	8.36***

Note: \*p-value < 0.10; \*\*p-value < 0.05; \*\*\*p-value < 0.01

Table 3. The regression estimations.<sup>6</sup>

Comparison of the coefficients of both models (see Table 3) shows that claimed eco-differentiation (i.e. the degree to which managers claim that the offer has a lower environmental impact than comparable alternatives) is the dominant variable. This is consistent with warnings in the practitioner-oriented green marketing literature (e.g. Ottman, 1998; 2011; Grant, 2007; Esty and Winston, 2006; Makower and Pike, 2009) that green communication can be a two-edged sword and produces positive outcomes only if the claim is credible and backed by evidence.

In light of these results, hypotheses H2a, H2b, H3a and H3b are consistent with the data, while hypotheses H1a, H1b, H4a and H4b are not.

## Conclusion

The study set out to investigate whether the general characteristics of an environmentally oriented offer could predict the perceived positive marketing effects of eco-communication and eco-credibility. My most surprising finding is perhaps that eco-efficiency has a weaker (if any) association with eco-communication than was expected. Also, eco-efficiency is *negatively* associated with the perceived importance of eco-credibility for marketing the offer. There was no evidence that financial performance is associated with eco-communication (or eco-credibility), which perhaps is less surprising given that firm profit is determined by so much more than the environmental orientation of its offers. In contrast, and in line with previous literature (e.g. Pacheco et al., 2010; Esty and Winston, 2006) both policy support and eco-differentiation are positively associated with both perceived usefulness of eco-communication and eco-credibility. This paper has thus contributed to our understanding of the factors determining the success of green marketing, and environmental communication in particular, for very small environmentally oriented firms.

For managers considering a marketing strategy for a new green offer, the study implies that communicating the low environmental impact of the offers to customers is most useful if: 1) the offer has a very high level of eco-differentiation; and 2) the offer has strong regulatory support which benefits customers directly, either via lower costs or by facilitating customer activities. Managers will likely find eco-communication less beneficial if the environmental benefits of the offer are related to reduced resource usage and savings by the customers, and even that eco-efficiency *reduces* the importance of eco-credibility. Perhaps stressing the environmental aspects of the offer might in that case distract from communication of the cost-reducing benefits of the offer.

<sup>6</sup> A series of diagnostic tests and evaluations were performed to increase the probability of unbiased coefficients and valid t-tests for the coefficients. To check for outliers, studentized residuals were examined together with leverage and influence of observations (Belsley et al., 1980). Residual normality was evaluated by examining the interquartile range and pnorm and qnorm plots in Stata 12. Homoscedasticity of the residuals was tested using the Breusch-Pagan (1979) test for heteroscedasticity. Multicollinearity was examined by the variance inflation factor (Petrucci et al., 1999). Non-linearity of the relationship between variables was examined using a scatterplot matrix. Model mis-specification was tested using the Ramsey (1969) RESET test. To evaluate issues of independence, scatter plots were produced from residuals versus industry classifications (2-digit NACE code) and business-to-business selling. Overall, both regression models seem valid.

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This study has some limitations which call for caution when interpreting the results. First, the sample is fairly small and is comprised only of very small firms located in Sweden. Broad generalizations over different types of firms or strong claims as to the strength of the associations identified are therefore not advisable. However, the relationships and lack of relationships identified do warrant further study, using a complementary and perhaps larger dataset. For example, the study does not control for industry differences, except latently in the measure of financial performance, because the small sample size in this study made this impractical. However, the average size of cross industry effects constitute a step forward in our understanding of when eco-communication facilitates the marketing of environmentally oriented offers. Second, the study uses firm financial performance as a proxy for the financial performance of the offer. In this case, this was sensible because the small size of the firms means that most of their revenue is derived from their main offer. However, use of this proxy might explain the lack of association between financial performance and eco-communication. Unfortunately, the difficulty of attributing profits to a particular offer might be methodologically challenging to resolve.

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### Appendix 1 –Survey questions and accounting data

**Eco-communication**, the dependent variable, estimates the perceived importance of communicating eco-differentiation for marketing the offer. It is treated as an interval variable and is calculated as the mean of the responses to two Likert-scale items. The two questions are: 1) (reverse scoring) "That we inform about the environmental strengths of the offer has no noteworthy impact on the sales of the offer"; 2) "A trustworthy claim of low environmental impact is important for marketing of the offer". The Pearson correlation between the two items is (-)0.47 ( $p < 0.001$ ). The *Eco-communication* variable has for the sample are respectively a mean of 5.45, a standard deviation of 1.22 and a median value of 5.67.

**Eco-credibility**, the dependent variable in the second model, estimates the perceived importance of making a trustworthy claim of eco-differentiation for marketing the offer. It is treated as an interval variable and is estimated based on the responses to item 2 above. The *Eco-credibility* variable has for the sample a mean of 6.00, a standard deviation of 1.08 and a median value of 6.00.

**Eco-efficiency**. The predictor variable eco-efficiency estimates the extent to which respondents believe that the offer's eco-differentiation is related to lower costs of ownership for their customers. The variable is treated as an interval variable and is calculated as the mean of the responses to three Likert-scale items. The three questions are: 1) "The offer's environmental strengths are clearly related to that the offer creates cost savings for the customers"; 2) "There is no clear connection between the offer's environmental strengths and that the offer creates savings for the customer" (reversed scoring); 3) "If the offer was remade to be similar to a typical less environmentally friendly competitor, then the offer would create fewer savings for the customer." The construct's Cronbach's alpha is 0.675. The *TCO* variable has for the sample a mean of 5.09, a standard deviation of 1.44 and a median value of 5.17.

**Policy support**. The predictor variable policy support estimates the extent to which respondents believe that governmental policy or regulation helps create customer value. However, it does not include government support which reduces the respondent firm's costs of production. The variable is treated as an interval-type variable, and operationalized as the highest value out of two underlying constructs. The two underlying constructs are the extent to which public policy helps: 1) reduce customers' costs of using the offer (e.g. tax breaks); or 2) create special customer benefits (e.g. free parking for eco-certified cars). After some deliberation, it was decided to operationalize policy support as the higher of the two underlying constructs. The aim was to create a single measure of policy support for the offer. Initially, an alternative combined construct was considered, defined as the product of multiplying the two underlying constructs. However, considering the situation of a respondent answering 3 (just below the middle of the scale) and 6 (near the top of the scale) for the two underlying constructs respectively, compared to a respondent answering 4 (the mid point in the scale) for both, it was judged that the former respondent's offer was likely to receive more policy support, even though the multiplicative product would be lower. Thus, the construct was operationalized as the higher of the two values for each respondent. The variable *Policy support* has for the sample a mean of 4.64, a standard deviation of 1.50 and a median value of 4.83.

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The two underlying constructs were estimated as arithmetic means of two groups of Likert-scale items. For customer cost-saving policy, the three items were as follows: 1) “The offer’s environmental strengths help the customers avoid some regulated or legislated costs that using some competing offers imply”, 2) “In terms of customers’ costs, legislation of public policy treats our offer favourably” 3) “There are not any effective laws of public directives that make customers’ costs for our offer lower than their costs for less environmentally friendly competing offers”.

For the second underlying construct: policy creating special customer benefits, the two items are: 1) “Thanks to the offer’s environmental strengths our customers enjoy certain benefits connected to laws or regulation”; 2) “There are not any (effective) laws or regulations that give buyers or users special benefits”. The two items were introduced by a short statement that customer cost benefits were related more to the previous three items, and that the items that followed referred to other types of customer benefits.

**Eco-differentiation.** The predictor variable eco-differentiation is a measure of the offer’s environmental performance. It estimates the extent to which respondents claimed that the offer’s environmental impact was lower than that of available alternatives. The variable is treated as an interval variable and estimated by agreement with the statement: “To use our offer creates a lower environmental impact than what is the case for most alternative solutions that the customers can choose from”. As for all items in the survey, the responses were scored from 1 to 7. However, because this survey item was used also to identify environmentally oriented firms (those indicating 5 or above), the range for eco-differentiation is 5-7. Thus, it measures the degree of eco-differentiation among all firms that scored fairly high on this attribute. The *eco-differentiation* variable has for the sample a mean of 6.5, a standard deviation of 0.80 and a median value of 7.

**Financial performance** was estimated using accounting data. First, the profit margin for each Swedish firm in the data set was calculated as profit over turnover. Next, a counterfactual profit margin was calculated as the weighted (based on standardized distance) average profit margin of the three firms that best matched each environmentally oriented firm in terms of industry classification, turnover, employee numbers and firm age. The financial performance of each environmentally oriented firm was calculated as its profit margin less the counterfactual profit margin. Thus, financial performance can range from -2 to 2, where 0 indicates that the profit margin of the firm is the same as its nearest neighbours, and financial performance different from 0 indicates that the firm is performing better (>0) or worse (<0) than its nearest neighbours in the economy. The measure of economic performance is quite independent of firm size, as indicated by the correlation matrix below:

	<i>Ecperf</i>	<i>Age</i>	<i>Turnover</i>
<i>Age</i>	0.18		
<i>Turnover</i>	0.13	0.56***	
<i>Employees</i>	0.20	0.35***	0.63***

Note: \* p < 0.1; \*\* p < 0.05; \*\*\* p < 0.01

Table A1.1. Correlation table indicating that the measure of economic performance is not correlated with firm size. Appendix 2 – Correlation table for the investigated variables

	Eco-communication	Eco-credibility	Eco-efficiency	Policy support	Eco-differentiation
Eco-credibility	0.76***				
Eco-efficiency	-0.1	-0.17			
Policy support	0.3*	0.19	0.21		
Eco-differentiation	0.40***	0.57***	0.00	0.13	
Financial performance	0.11	-0.08	0.04	0.22	0.10

Note: \* p < 0.1; \*\* p < 0.05; \*\*\* p < 0.01

Table A2.1. Pearson correlations between the variables.

## Integrating Thermodynamics and Biology for Sustainable Product Lifecycle Design

Victor Martinez  
Postgraduate Researcher  
Centre for Design Research, School of Design  
Northumbria University  
UK

Stuart English, Programme Leader  
Centre for Design Research, School of Design  
Northumbria University  
UK

Matteo Conti, Senior Lecturer  
Centre for Design Research, School of Design  
Northumbria University  
UK

Kevin Hilton, Postgraduate Researcher,  
Centre for Design Research, School of Design  
Northumbria University  
UK

### Introduction

The link between the consumption of natural resources and economic growth through product manufacture and disposal (cradle to grave) is creating an untenable pressure on the planet's ecosystems (Heinberg, 2007; Meadows, 2004; McDonough, 2002; Krugman, 2008; Stern, 2007; Stiglitz, 2010).

Furthermore, the index used by nations around the world use to measure economic growth is Gross Domestic Product (GDP); this is "the sum of all value added to raw materials by labour and capital at each stage of production, during a given year" (Daly and Farley, 2004). From this definition it can be inferred that the more efficient labour is, the less capital is needed and more added value can be achieved. This principle drives technological improvements, and underpins a continuous search for efficiency; which in turn creates another complex linkage with the balance of unemployment (Jackson, 2009). In order to keep people employed and avoid social collapse more products must be created.

This trend is well defined by Jevons' paradox (1865), where technological efficiency instead of easing pressure on the planet and people, creates more demand, consumption and dependency. The way we design, build and use products, and even keep social cohesion is based on a constant structural need for avoiding collapse, fed by positive feedback loops that only increase its negative impacts.

This model for economic growth ignores one crucial objective: bringing wellbeing to people. The strongest evidence of this is in the relationship of the Human Development Index and GDP per capita; figure 1 shows that after a certain level of income is achieved there is little to no impact on human development. This figure also clearly shows a more dense area in low-income countries and hence illustrates the unevenness of the macro economic system (HDR UNDP, 2011).

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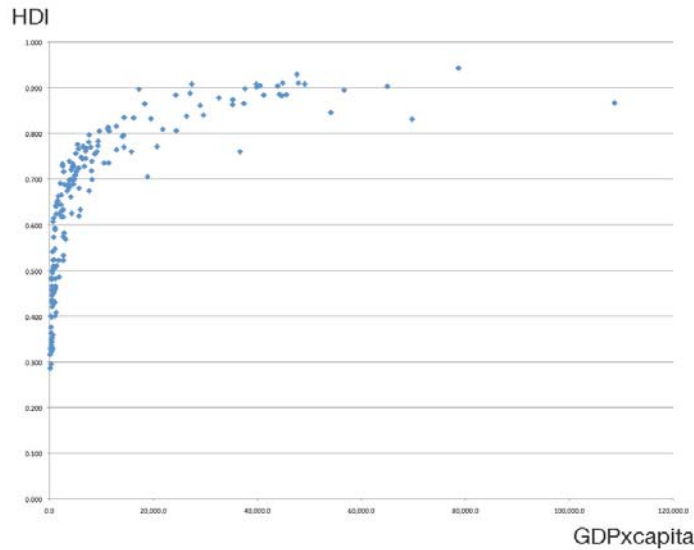


Figure 1 HDI vs GDP per capita

Previous research into macroeconomics frequently raises the question: what size the economy should be? If it is accepted that macroeconomics is not an isolated system but a subsystem dependant on the Earth's ecosystem services (Daly, 1991) it is physically impossible to sustain perennial growth within the current model (Georgescu-Roegen, 1999; Latouche, 2009; Daly and Farley, 2004; Meadows, 2004). With this idea present, size and distribution (GundInstitute, 2011) of businesses become key to achieve long term sustainability as well as to empower local development, biodiversity protection and thus a more equitable human development.

By taking this biophysical approach (TEEB, 2010) the direct relationship between economics and natural systems emerges through the laws of thermodynamics. In the natural world energy and matter are transferred and exchanged under very specific rules that have allowed living organisms long term sustainability for more than 3 billion years.

Numerous attempts have been made to value and measure ecosystems services and to assess the impact of human activity through thermodynamics. 3 possible calculation methods have been used: entropy (Kleidon, et al. 2010), emergy (Almeida, 2010; Odum, 1996 & 1998; Bastianoni, 2007; Brown, 1999; Jorgensen, 1995; Hau, 2004a; Ulgiati, 2009) and exergy (Sciubba, et al. 2008; Hua, 2004b; Bakshi, et al. 2011). All of these require highly specialised knowledge and data to inform large system analysis, this is complicated to obtain and very limited in it's scope.

The design field offers multiple initiatives to empower sustainability, for example: Okala Design Guide, Designers Accord, Natural Step, Total Beauty, Biomimicry, Natural Capilalism, Cradle to Cradle, Sustainability Helix, Sustainability Scorecards, Living Principles; there are many coincident points within different perspectives, but Shedroff (2009) summarises its very clearly: "One serious problem for designers is that, even with a systems approach, there are few tools in existence that wrap these issues together. Instead, designers must learn to match together a series of disparate approaches, understandings, and frameworks in order to build a complete solution".

### Motivation

Designers are, by active association, responsible for the pressure on Earth's ecosystems and much of the impact can be traced back to the early stages of the design process. For designers and engineers the main constraint is accessibility to knowledge of multiple and complex factors in an easily digestible form even before starting a project. Added to this is the possibility to transcend the realm of products and explore creative solutions throughout the entire life cycle, giving designers the opportunity to propose entire new business models and systems.

Schwab (2012), questions whether capitalism is not being replaced by what he calls "talentism" as he states that: "capital is being superseded by creativity and the ability to innovate".

**Question / problem**

The principal goal in seeking long-term sustainability is decoupling which means “reducing the rate of use of resources per unit of economic activity” (UNEP, 2011; OCDE, 2002).

On the other hand there is the above-mentioned lack of integration of multiple and complex factors in today’s design practice. Interestingly Schumpeter (1954) states that every analysis starts with a preanalytic cognitive act he calls “vision”, whatever is not included in that preanalytic vision cannot be reckoned by ulterior analysis.

Therefore, such an integrating tool must be directed to allow the creation of the preanalytic vision, even before any analysis on the matter is performed. This concept is more easily explained in figure 2, the first section refers to Shedroff’s view, where multiple and complex factors “must be learned” by designers, leaving in this way sustainability solutions dependant on designer’s personal awareness, skills and interest.

The aim of this research is represented by the second section: focusing attention on the solution; using a tool to create the “preanalytic vision” in order to produce sustainability solutions within the project boundaries and relying on the group’s creativity. In other words, turning sustainability problems that would need to be mitigated at a later stage, into creativity problems that prevent those issues before they actually occur.

Hence in a decoupled economy: what will products look like? How, where and who will produce them and through which business model will they reach users?

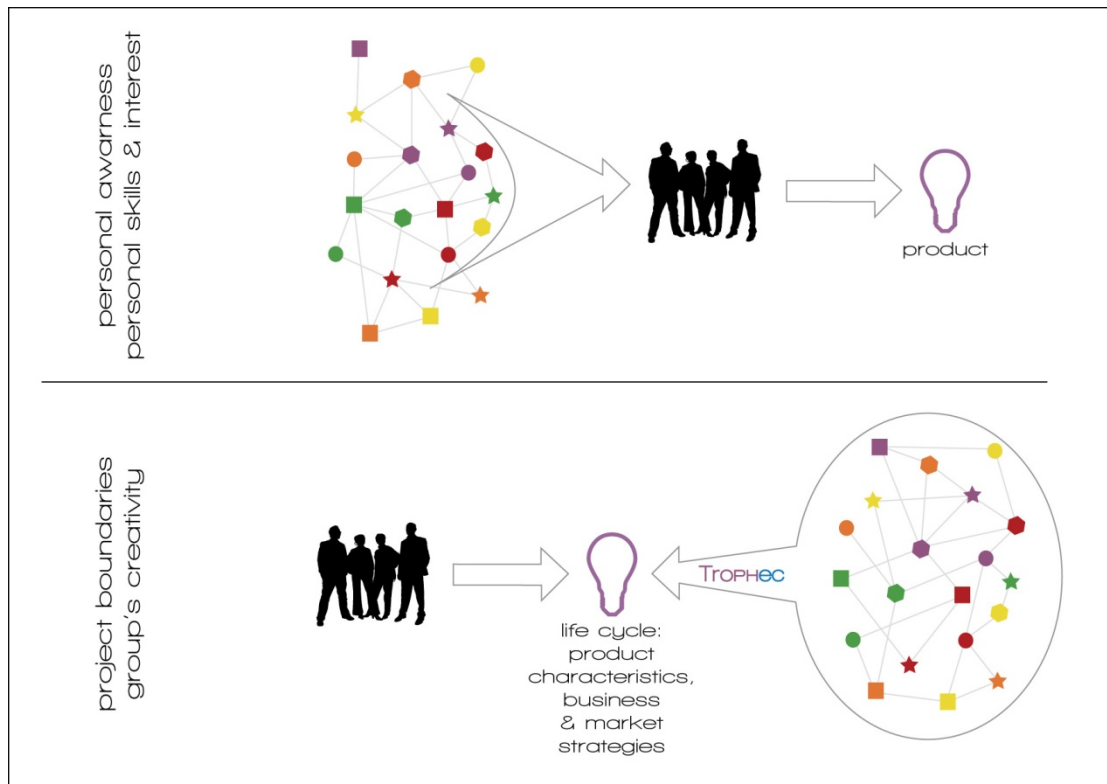


Figure 2 Facing complexity or focusing in the solution

**Aims**

This paper exposes the search for an intuitive soft modelling tool that considers multiple and complex factors in order to achieve long term sustainability and inspire the innovation of businesses and systems from a biophysical perspective. The aim of this tool is to enable the creation of a preanalytic vision, so that sustainability issues are revealed in response to the designers’ creativity and innovation.

## Tool development

The first key question in the development of this approach has been: how does it work in nature? Organisms search for their food in other organisms, which at the same time become the food of others. Throughout this process biomass and energy are transferred from one level to another, losses occur, higher qualities of energy are created and all is maintained in continuous cycles (Mader, 2010). Similarly the linear human production of goods can be rethought by taking into account this basic principle of thermodynamics, although this is not a technological problem, the relevant constraints need to be integrated for this approach to be feasible. These are from an economics origin: how can a healthy business be achieved from a non-linear process? An analogy between natural and human systems is proposed: autotrophs = producers, heterotrophs (herbivores) = distributors and (carnivores) = consumers (figure 3). Also considered is their concentration and size, including all the possible combinations as well as their eventual business interpretations; this is referred to as Trophic Economics (figure 4).

The envisioned tool will combine the exploration of the complex factors involved in the lifecycle of a product with the suggested Trophic Economics models. The outcome could be referred to as sketches of the possible boundaries and structures of new business and products in their entire life cycle, to be resolved later on the drawing board (figure 5). Some of the factors are not directly related to the product or its life cycle, but rather to the context (country) where the raw materials will be extracted, where the product will be manufactured and where it will be used (figure 6).

### Trophic levels correlation

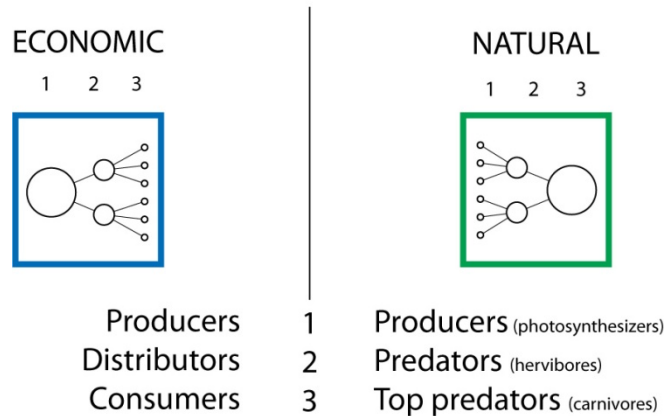


Figure 3 Trophic levels correlations

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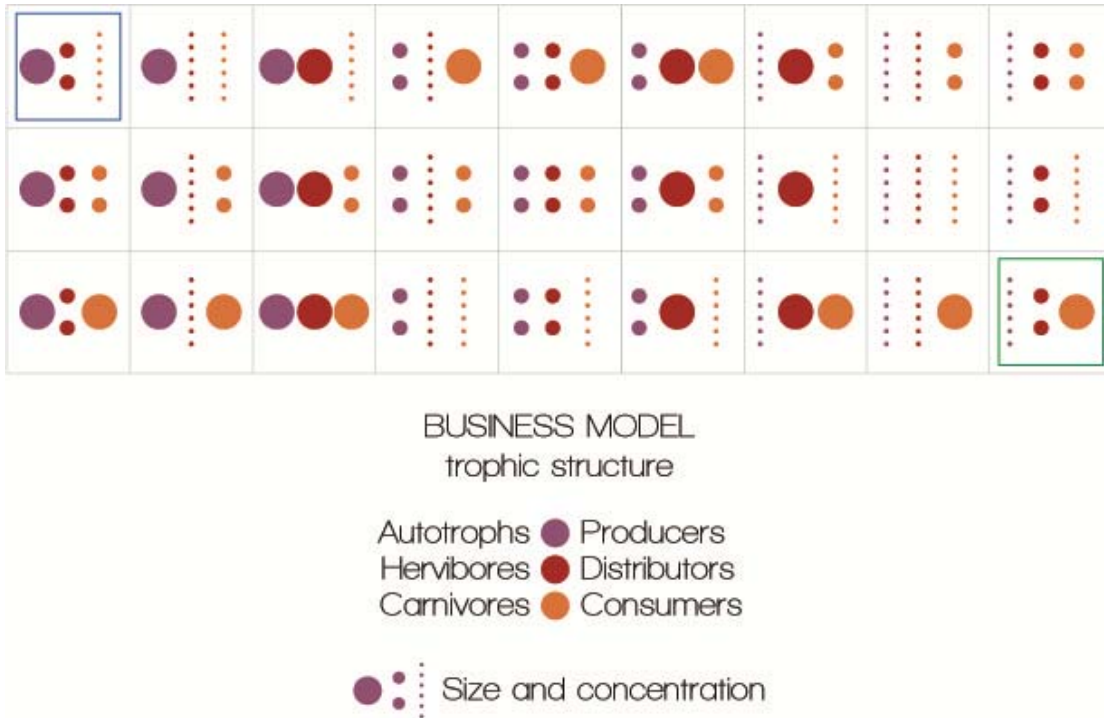


Figure 4 Trophic Economics diagrams

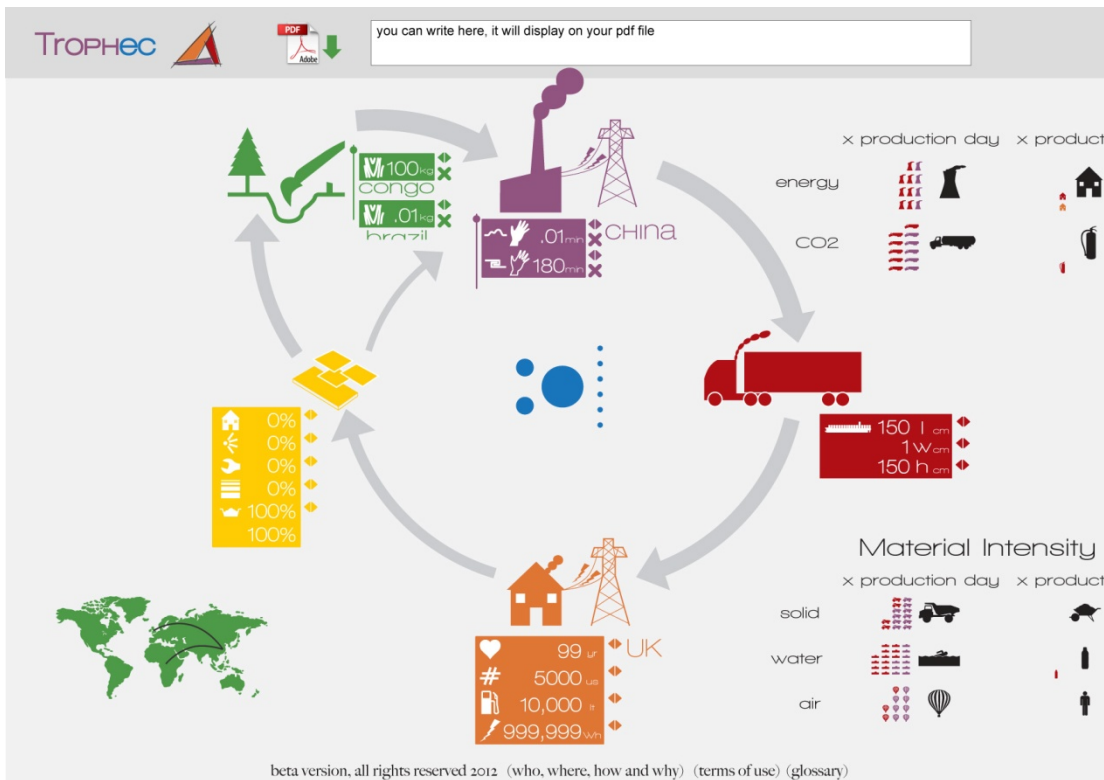


Figure 5 Life cycle sketch

The proposed tool's name is Trophec, as a short term for Trophic Economics. This is a web-based application that calculates the energy embedded, CO<sub>2</sub> emissions and material intensity in terms of solid matter, water and air accounted by single product and for one day of its production. The tool operating model is based on the research on carbon and energy inventory of Hammond and Jones



(2008), the material intensity by Wuppertal Institute (Ritthoff, et al. 2002) and several indexes and data bases from: International Energy Agency, United Nations Environmental Program, United Nations Development Program, United Nations, The World Bank, World Resources Institute, Central Intelligence Agency from the U.S. government and the Department for Environment, Food and Rural Affairs from the United Kingdom.

The application allows the designer to visualise in simple terms the entire life cycle, including recycling, business factors and the impact these have on the above-mentioned calculations. The designer builds their sketch map (Figure 5.) step by step as they provide *estimates* or *known's* addressing each aspect of the cycle in turn. This content construction process is itself educational to the design experience, in enabling greater appreciation of factor interrelationships. Once the designer has completed the initial setup, all figures can be easily changed and in real time the impact visualised; for each set of results the user can save a PDF file; this is intended as the sketch of the life cycle and just like product sketching it is based on flexibility, speed and comparability.

These sketches are intended to be a playful way to create the preanalytical vision discussed previously, enabling designers to concentrate on what they do best: solving problems through creativity and innovation within the set technical and business boundaries.

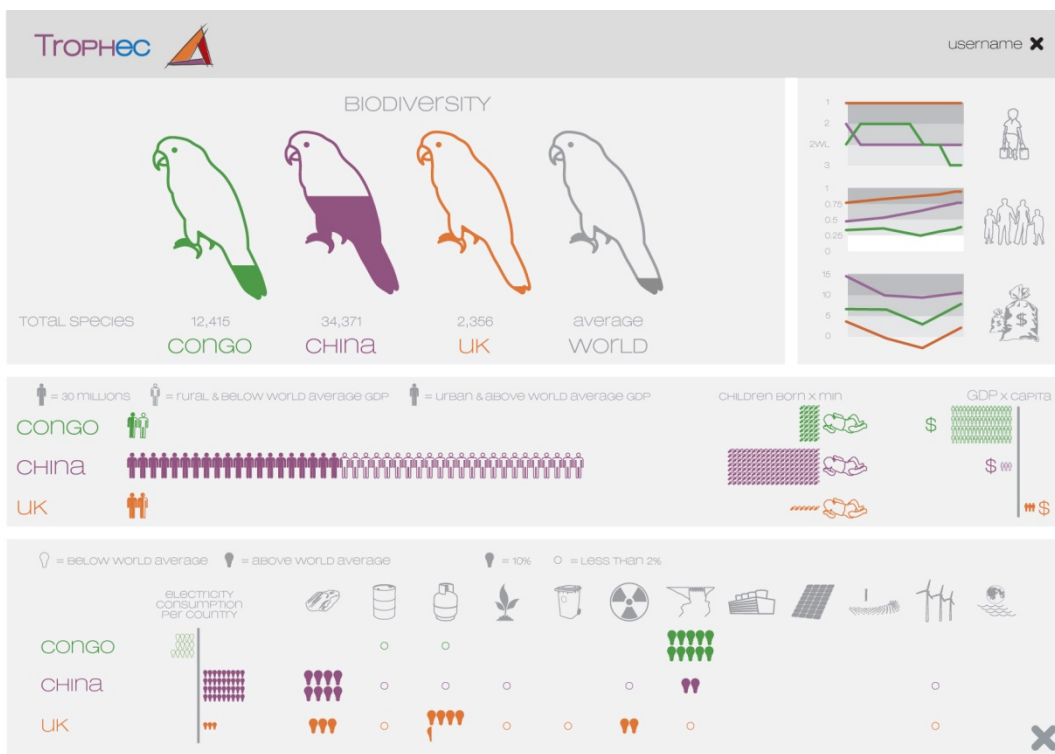


Figure 6 Countries infographics

A preanalytical vision, dynamically generated by the Trophec software integrates relevant economic, social, demographic and ecosystems information regarding the countries involved in any given sketch. Specifically: Biodiversity (total number of species), Child Labour and Slavery Tier, Human Development Index, national GDP, country population, urban and rural population, population growth, per capita GDP, country's electricity consumption and country's electricity production sources.

All this data is displayed as an infographic in order to make it visually concise and easy to use.

## Conclusion

Many current sustainability problems are directly related to the way our macroeconomic systems are configured, in the way we produce, sell, use and dispose of products. Thus the design processes used to create them is at the top of the impact chain.

A number of tools and guides have been created to improve the sustainability of products, however these are dependant on individual designers' ability to process large amounts of complex data (fig 2).

By understanding the principles that allow long term sustainability in natural systems, (on which our macroeconomics system rely), we can transform our approach to product and business configuration, with the aim of achieving more equitable human development at the same time as releasing pressure on the depletion of the Earth's resources.

Therefore, as a response to these two statements, the need to create a preanalytical vision was discussed and to test this a tool has been developed. It is thought that this research could catalyse further discussions about the approaches taken by the design community and the future possibilities for design professionals.

### Future work

The concept of Trophic Economics is in a very early stage, more research is necessary to better understand its correlations and implications in a possible integration to real-life business. It is not clear how this concept could empower local development by encouraging different business models of local and small but global enterprises, as well as its implication to resources usage.

Regarding Trophic, the tool will be tested internally in the School of Design at Northumbria University in the last months of 2012. At the beginning of 2013 it will be made public and design schools and various design professionals from all over the world will be invited to use it. The data gathered will enable us to better understand the creation of the preanalytical vision and its correlations and impacts on product and business design.

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# The Requirements Management Framework as a Support Tool for Designing Sustainable Product-Systems

Ângela Maria Marx

PhD student, Industrial Engineering

Federal University of Rio Grande do Sul

Porto Alegre, RS

Brazil

Istefani Carísio de Paula

Professor, Industrial Engineering

Federal University of Rio Grande do Sul

Porto Alegre, RS

Brazil

## Introduction

New Product Development (NPD) is a process that goes beyond the organizational boundaries, impacting suppliers, customers, the environment and the society. There are some innovation approaches that include these stakeholders in the creation of products and services, as co-creation (Prahalad, Ramaswamy 2004; Sanders, Stappers 2008). However, companies committed with Sustainable Development may find difficulties to spread the company principles to the development team and partners, resulting in products and services that poorly reflect those values.

This paper aims to demonstrate the application of a Requirements Management Framework (RMF) focused on sustainability in the project of a biodegradable diaper-system for public hospitals. This framework was theoretically presented in previous papers (Marx, Paula 2009, 2011) but the practical implications of the RMF in driven a more sustainable NPD process were not detailed.

## The Requirements Management Framework (RMF)

Requirements are usually originated from demands and deployed into product functions throughout the NPD process. A requirement can be conceptualized as a feature that the product-system must attend to satisfy a demand or to achieve a stakeholder goal, qualified by measurable conditions and bounded by constraints (Marx, Paula 2011). Additionally, they have a series of quality attributes, as clarity, consistency, completeness, non-redundancy, among others (Kotonya, Sommerville 1998; Young 2003).

Requirements can be classified as functional and non-functional (Kotonya, Sommerville 1998; Young 2003; Parviainen, Tihinen & Solingen 2005). Functional requirements are those related to technical functions, i.e., correspond to actions defined by inputs and outputs that the product-system should be able to perform without considering physical constraints. Non-functional requirements, in turn, determine how the product-system should operate in a global way, imposing restrictions on the functions and solutions of the functional requirements (Pahl, Beitz 1996; Kotonya, Sommerville 1998; Jiao, Tseng 1999; Young 2003; Parviainen, Tihinen & Solingen 2005).

In a sustainable project the number and complexity of non-functional requirements may increase considerably, imposing many constraints for the solution that are difficult to visualize. The RMF proposed by Marx and Paula (2011) can be applied to any NPD model as a tool to organize the information among the project bringing the relations between functional and non-function requirements into light.

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The framework resulted from the analysis of the requirements activities presented in some NPD models (Creveling, Slutsky & Antis 2003; Pahl et al. 2005; Abele, Anderl & Birkhofer 2005; Rozenfeld et al. 2006) and in the Requirements Engineering process used in Software Engineering (Kotonya, Sommerville 1998; Young 2003). It includes all the activities present in the models studied and fills the gaps left by them, which are:

- the inclusion of demands of other stakeholders than customers;
- the consideration of requirements for the subsystems related to the product;
- the inclusion of mechanisms for conflict analysis and change control.

The analysis also indicated that the business requirements are not usually verbalized in most models. For this reason, the insertion of a strategic step to gather the company requirements was considered essential to a RMF focused on sustainability. It is assumed that the development of a truly sustainable product will only take place if the organization is committed with sustainability in its three dimensions: environmental, social and economic.

It can be concluded that if a company is committed with sustainability, this will be expressed in its business objectives. Then, it is possible to derive sustainability requirements from the business objectives (Young 2003; Chesbroug, Schwartz 2007) and, considering these requirements during the NPD, the company will be able to develop sustainable products aligned with the business goals. The RMF resultant is illustrated in Figure 1 related to the phases of a generic NPD process.

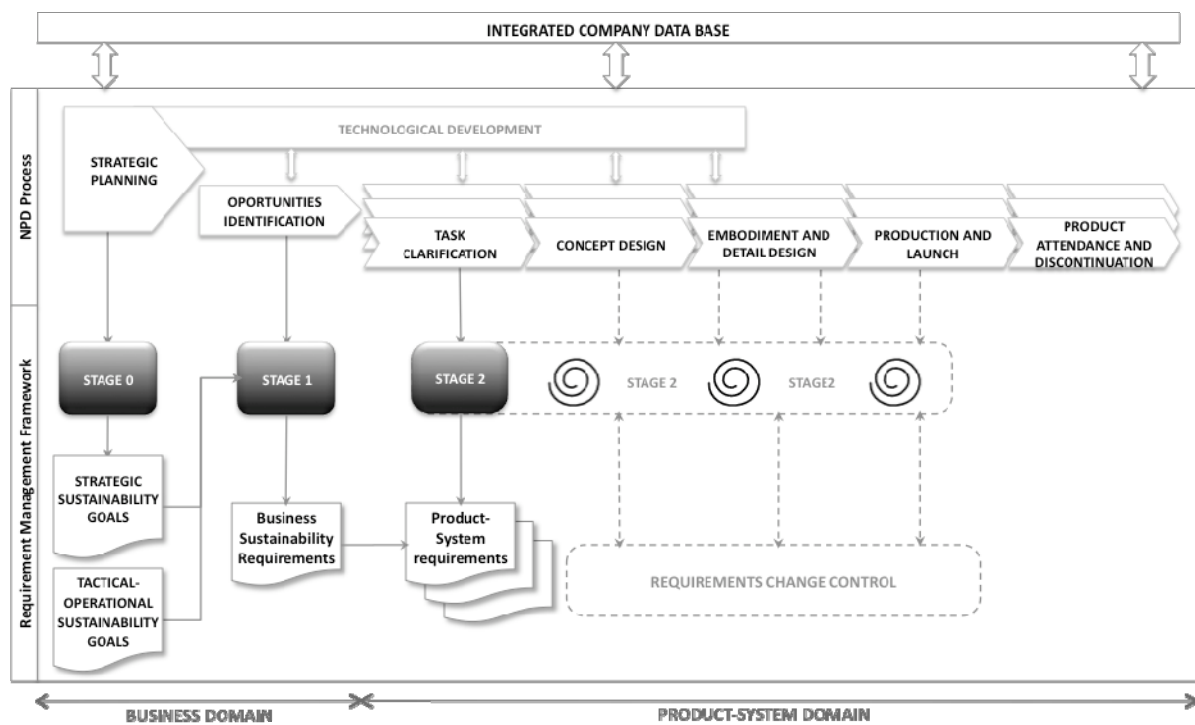


Figure 1. The requirements management framework

The RMF is composed by three stages and eighteen tasks. Stages zero and one are of strategic nature, reason why they should be executed during the company strategic and portfolio planning. The purpose of these stages is to define the business sustainability requirements from the business goals. The first stage is called zero because it is optional. If the company has already defined sustainability business goals this stage is skipped, otherwise it is necessary to set environmental, social and economic business goals that can be of strategic and/or tactical-operational nature. In stage 1, the sustainability business goals are decomposed into sub-goals and subsequently into non-functional requirements using the process described by Loucopulos and Karakostas (Kotonya, Sommerville 1998). The business requirements generated in these stages are generic and will be used as a roadmap in the development of all company's products.

Stage two contains the tasks concerned with the requirements of one specific sustainable product-system, to be performed from the NPD front-end. The activities identified in the analysis of the models were grouped in the four main steps presented in the management requirements theory: elicitation, analysis/ negotiation, documentation/ validation and change control. Figure 1 demonstrates that these

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steps are iterative and can be repeated along the NPD process, depending on the product-system characteristics and its innovation grade. Some tasks of the fourth step can also be performed in parallel with the others. Figure 2 presents the main tasks involved in this stage.

STAGE 2	
<i>ITERATIVE STEPS</i>	<i>TASKS</i>
Elicitation	1. Mapping the scenario
	2. Identification of stakeholders
	3. Elicitation of stakeholders needs and demands
	4. Conversion of needs and demands into requirements
Analysis/ Negotiation	5. Conflict analysis, negotiation and prioritization of the requirements
Documentation/ Validation	6. Elaboration of the requirements document
Control of changes	7. Conversion of requirements into functions
	8. Deployment of requirements for product components
	9. Control of requirements changes

Figure 2. Tasks proposed for the definition of the requirements for a sustainable product-system

### Case Study: The Diaper System

The case was conducted within two projects supported by CNPq, the Brazilian Research Council. The first project, called Inclusion Factory, gave the strategic directions to the second project, focused on the diaper-system.

The Inclusion Factory is a project focused on the conversion of residues into products in a systemic and sustainable manner. The project follows the Sociotechnical Design parameters that are the fulfilment of people basic needs, the end of residue generation and the environment regeneration (Guimarães et al. 2006) in addition to the cradle-to-cradle approach based in techno cycles and/or bio cycles.

The main goal of the project is to fulfil some social needs detected in the state of Rio Grande do Sul, Brazil, using the residues of the regional activities as rice straw and husk, wool and leather from slaughter process, and viniculture. Among the products being developed for the Inclusion Factory are: shoes and clothes for the uniform of children in Brazilian public schools, a diaper-system for hospitals, etc.

#### Stage 0: Definition of the Inclusion Factory business sustainability goals

The Inclusion Factory was conceived to promote the sustainable development of the region in which the plant will be installed. The overall business goal is “*Develop sustainable solutions from residues*”, with one business goal set for each sustainability dimension (see Figure 1).

These sustainability strategic goals and the sub-goals directly related to them were established during the Inclusion Factory strategic planning. Unlike, the goals for the tactical-operational level were not defined because the processes were not designed at that point. So, the researchers organized a business meeting with the Inclusion Factory managers to establish how the main manufacturing areas of the enterprise (marketing, product development and production) will contribute for the achievement of the sustainability strategic goals and sub-goals.

As an example, some of the sub-goals set for the product development area were: “*Develop products that promote an improvement in the quality of life of customers and workers*”, “*Use residues that are locally available*” and “*Minimize the environmental impact in the products life-cycles*”. Figure 3 illustrates the strategic goals deployment, demonstrating the origin of the quoted sub-goals.

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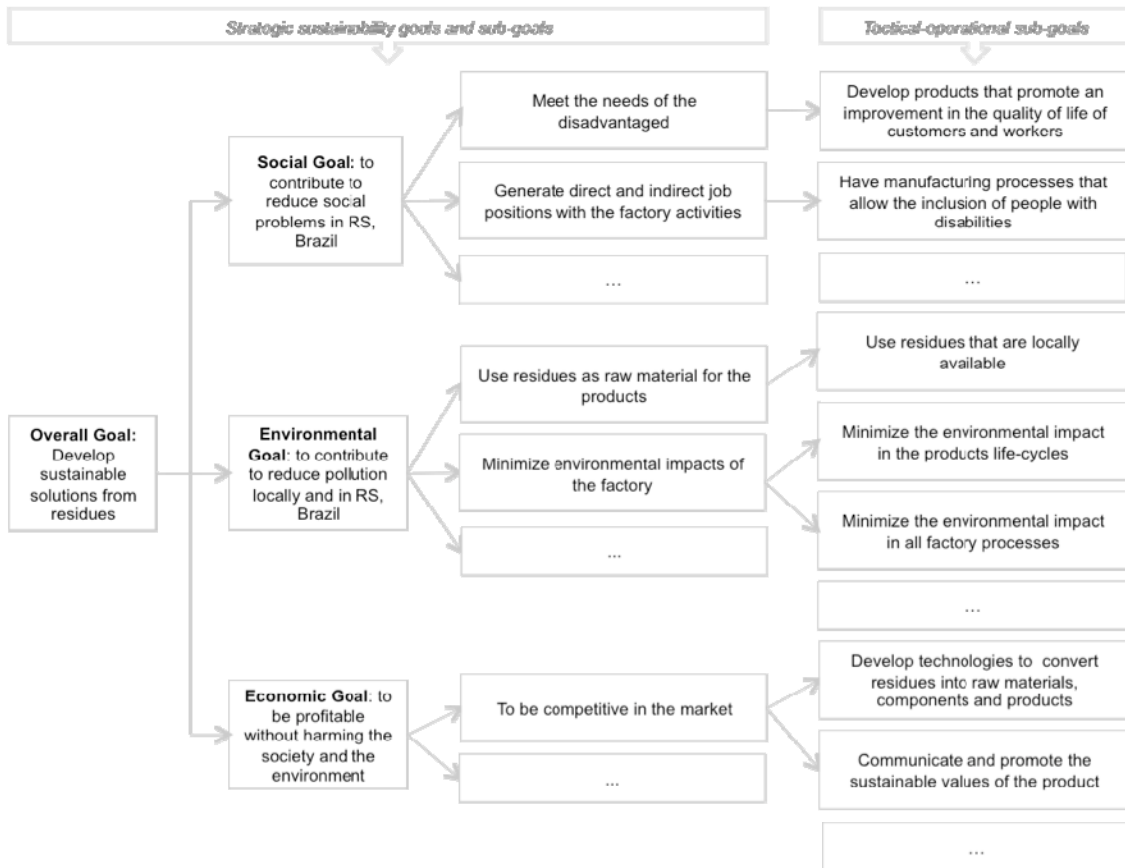


Figure 3. Business sustainability goals deployment in strategic and tactical-operational levels

### Stage 1: Definition of business sustainability requirements for the Inclusion Factory

After the definition of the business sustainability goals, they were deployed into requirements. The process begins with the statement of the business goal followed by the question “*What is necessary to achieve this goal?*”. The answer is placed in a sublevel and deployed again until a measurable non-functional requirement can be defined. This derivation process is exemplified in Figure 4, in which the goal “*Minimize the environmental impact in all factory processes*” generated requirements that set important parameters for the Inclusion Factory processes, as maximum temperature, maximum distance for raw material transportation and maximum consume of water.

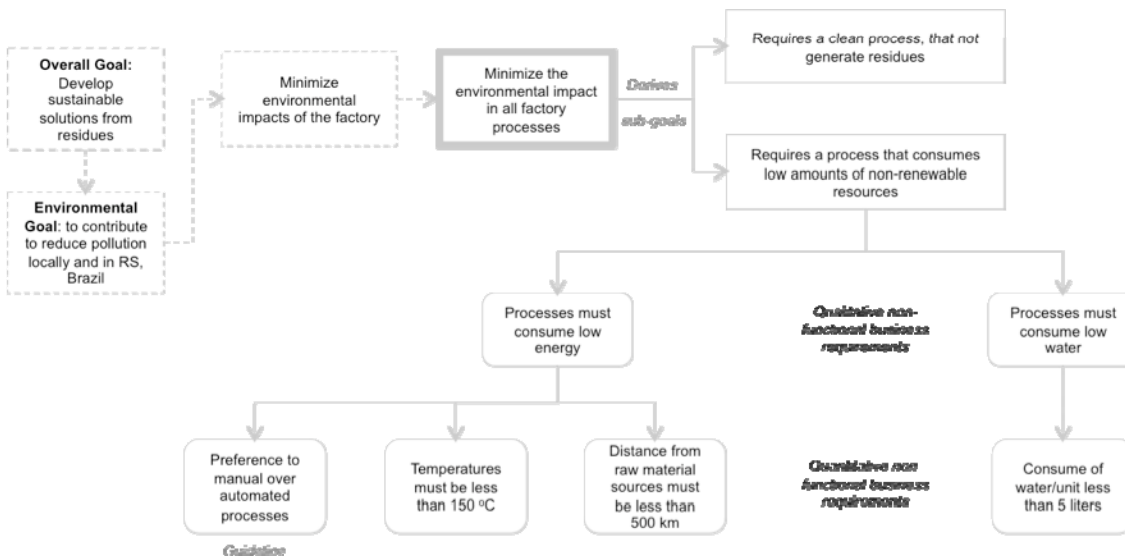


Figure 4. Derivation of non-functional requirements from the sustainable business goal “*Minimize the environmental impact in all factory processes*”

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During this process, we observed that some answers for that question were not exactly requirements, but guidelines. This situation is illustrated in Figure 4 by the statement “*Preference to manual over automated processes*”, that is a recommendation but not an imperative. In fact, we obtained much more guidelines (56) than requirements (24) in the end of the derivation process. These guidelines were organized in a list to be used as a reference.

The sustainable business requirements identified in stage 1 were organized in a requirements document, to be used as the initial requirement list for each new product. These requirements were also graphically organized by dependency relationship in a tree diagram representing the roots of the new products. Figure 5 has a partial view of the original diagram for the Inclusion Factory.

During the new product-system development, the upper part of the diagram is filled with specific requirements and the dependencies and conflicts more easily identified. The business requirements are generic and non-functional, reason why they were maintained separated from the specific requirements in the lower part of the diagram. Although, it is necessary to keep the business sustainability goals in mind during the whole design process, as they set boundaries for the solution.

### Stage 2: Definition of requirements for the sustainable diaper-system

The diaper-system is part of the Inclusion Factory line of products that fulfil hygiene and health needs. It consists in the development of a biodegradable diaper-system for public hospitals, assembled with materials originated from regional agriculture residues. The project is running since 2008 supported by CNPq, and it is conducted in partnership with other research institutions and one private company.

Differently from other products in the Inclusion Factory, a disposable diaper for hospitals cannot be converted in another product after the use, but it is compostable. In this case, it would be necessary to rethink the product systemically: biodegradable materials, production process, disposing system for the hospitals, reverse logistics, treatment system, and so on. Each element in this diaper-system has particular requirements deeply dependent of other elements' requirements, reason why it is important to identify and manage them since the project front-end.

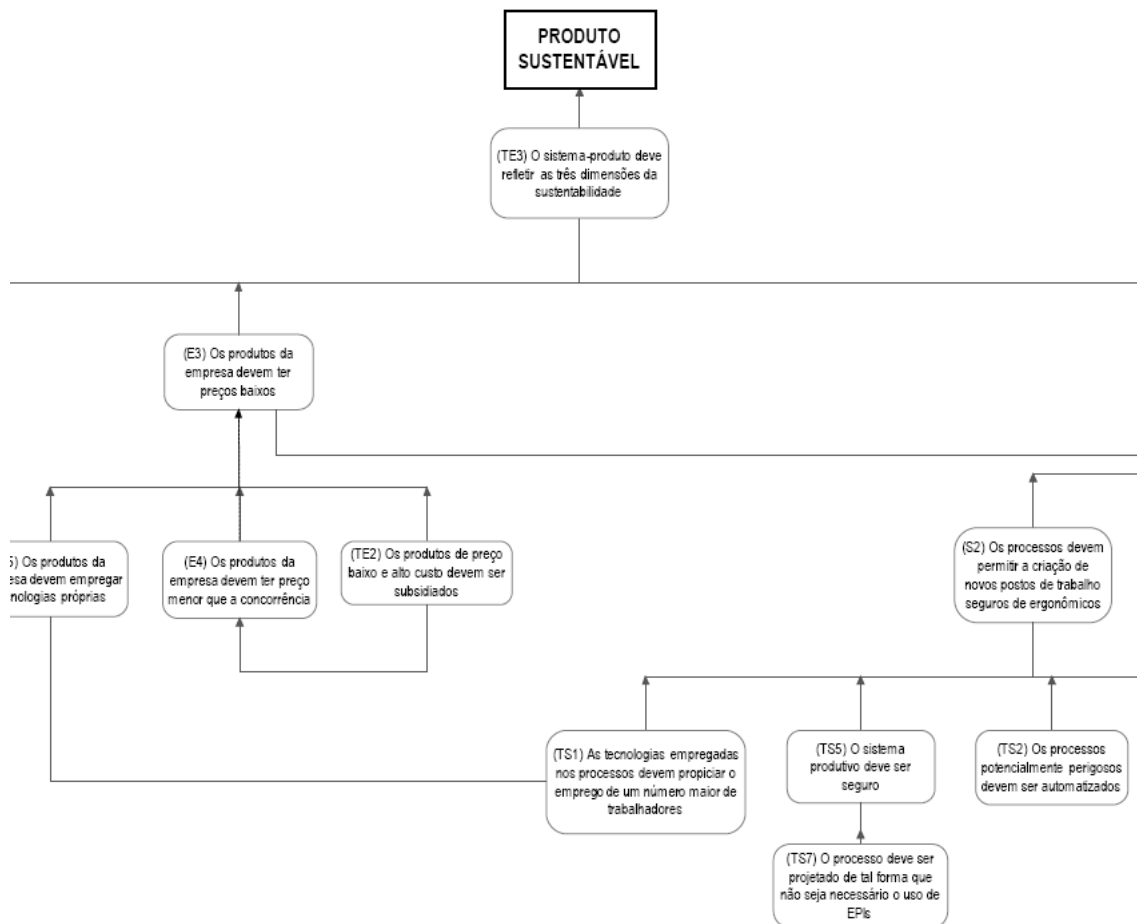


Figure 5. Part of the original sustainability business requirements diagram



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In the beginning of the diaper-system project, all information available was analyzed. The sources were interviews with hospital personnel, market research, preliminary laboratorial tests, literature research, Inclusion Factory reports, among others. It was possible to map the scenario, the stakeholders, the main elements that will be part of the system (product, materials, technology, process, end-of-life, packaging, market, etc) and some specific requirements for these elements.

There is no difference in these activities from any NPD process, unless a greater attention to other elements of the system. The requirements identified were allocated in the upper part of the tree diagram, grouped by system element, and the dependencies were marked. The diagram is useful to visualize the conflicts between the requirements for different elements of the system in the first stages of NPD. It facilitates the negotiation between requirements and minimizes problems in further NPD stages, especially if there are more than one team working in the project. This diagram is very large and it will grow fast as the project moves forwards. Figure 6 presents an idea of the size of the initial diaper-system diagram.

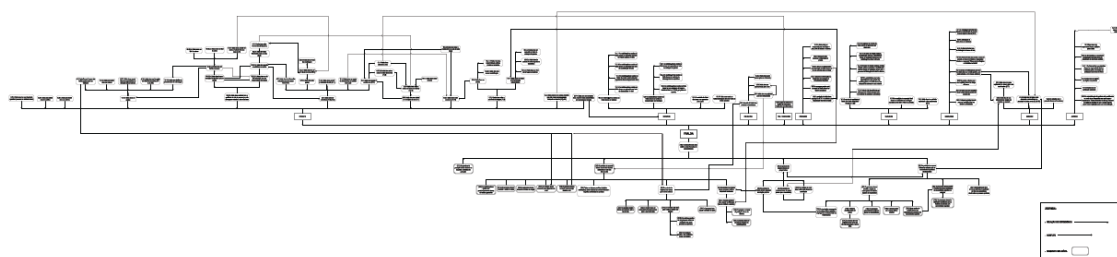


Figure 6. Overview of the first requirements diagram for the diaper-system

The main challenges of the project were related to material and technology, especially the obtainment of cellulose pulp from the vegetable waste. The reason is the difficulty to achieve the quality standards required for absorbent pulps under the constraints imposed by some business requirements, as the use of residues locally available, the restriction of water and energy spent in the process and the non-generation of hazardous residues.

Many trials were made to convert rice straw, one of the main agriculture residues in south Brazil, in absorbent pulp but they all have failed. Other tests were performed with the King Palm (*Archontophoenix alexandrae*) leaf sheaths, a by-product resultant from the industrial processing of canned heart of palm in the region (Seben, Paula & Viana 2012), until an acceptable cellulose pulp was obtained in a process that fits the business requirements.

A similar situation happened with the outer part of the diaper, usually made of a polyethylene (PE) film. It should enclose the absorbent part, be made of a waterproof material to protect the user from the urine and also comply the sustainable business requirements: be biodegradable and made from residues found in the region. The market of biopolymers grows fast, but we couldn't find residues of these materials to use in the diaper-system.

In the absence of such residues, the compliance of both business requirements became unfeasible and the project team had to decide if it would be better for the diaper-system to use plastic residues that are not biodegradable or to use compostable virgin plastic. The impacts of both choices were evaluated considering the dependencies expressed in the diagram: the use of a non-biodegradable polymer will change completely the disposal system and will be in conflict with other requirements, as the non-generation of residues. On the other hand, the use of a non-residue will not affect other requirements.

After the negotiation between the requirements, the developers started to work in a compostable polymeric film made with virgin polymers. The tests were performed with blends of PLA (polylactic acid) and PBAT (Poly(butylene adipate-co-terphthalate)), and it was possible to produce in laboratory scale a polymeric film that is biodegradable under composting conditions and meets the standards of the PE film used in traditional disposable diapers.

At the present, the project is in the prototyping phase to confirm (or not) the adequacy of the materials developed for the diaper-system. The other elements of the diaper-system are in different stages of development.

### Conclusions

The RMF presented in this paper is a tool to align the NPD process to the company principles and values but also a tool to organize the information among the project. It was conceived thinking in companies dedicated to create sustainable products and services but it can also be applied for organizations that focus other objectives in other issues.

We demonstrated how the sustainable business requirements resultant from stages 0 and 1 were considered during the development of the cellulose pulp and the compostable polymeric film. The construction of the diagram was useful to set the dependencies between the requirements and to evaluate how a choice will impact the whole system that is being designed.

It is important to make clear that the RMF does not impose any specific tool or method to perform the tasks in stage 2. This fact reinforces the applicability of the framework to any NPD process, and allows the development team to choose the tools that best fit each project.

### Acknowledgments

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## Developing An Organization Culture To Facilitate Radical Innovation

Dr Patrick McLaughlin  
Senior Lecturer  
Manufacturing and Materials Department  
Cranfield University  
Bedford  
UK

### Abstract

This paper describes an approach to organizational development to stimulate an innovation culture for radical product development in a medium sized mature engineering company. An exploratory study within a “live” new product development team surfaced key aspects of a radical innovation culture. Nine key themes were found to be pertinent, following an intense period of investigation using face to face semi-structured interviews and focus group exercises. These themes were triangulated using the established OCAI Organization Culture Assessment Instrument and the KEYS Creative Climate Assessment Tool. Seven actionable interventions were developed in conjunction with the company’s NPD team, senior managers, the interrogation of previous empirical case research and active dialogue with UK companies that promote discontinuous innovation. The results of the interventions are evaluated four years after implementation. The outcomes indicate the success of the company’s attempt to embed a sustainable radical innovation culture into the product development area.

### Introduction

There has been extensive discussion about challenges posed by what have variously been called “disruptive”, “discontinuous”, “breakthrough” and “radical” innovations. (Christensen and Raynor, 2003; Hargadon, 2003; Kaplan et al., 2003; Laurila, 1998; Trott, 2002). Although the nomenclature may vary, under conditions in which the “rules of the game” change, even businesses with well-developed innovation capabilities can run into difficulties (Bessant et al., 2005).

The Company that hosted this research is a small design and manufacturing business which is part of a larger UK PLC. Design, development and manufacturing are all carried out exclusively at the UK facility. Established in 1961, the company had grown to be a dominant player in its international market sectors but found itself unable to provide the “stream of innovative new products” that the competition were delivering. It had a robust new product introduction process that had been used to generate “me too” products that were responding to competitor offerings by developing an evolution of an existing product. In early 2000, the company embarked on a programme to develop a new-to-company, new-to-industry instrument. Early attempts to create this “radical” product were unsuccessful, despite investment in consultancy support for development. The company subsequently undertook research focused on developing a radical innovation capability. At the time of this research, the company employed 100 people.

Christensen (1997) noted the difficulties of following existing customers and suppliers too closely within particular value networks. Day and Schoemaker (2004) indicate the need to develop better peripheral vision to avoid being caught out by emergent technology developments. Mature companies face problems in reframing their underlying mind-sets and hence their response to take account of radical shifts in their operating environment (Foster and Kaplan, 2002; Leonard-Barton, 1992; Tripsas and Gavetti, 2000). Such companies often develop different operating processes and policies which may actively conflict with those routines developed for handling innovation under more steady state conditions (Francis et al., 2003; Leifer et al., 2000). Their concern is about managing innovation in two different modes – what March termed “exploitation” and “exploration” (1996).

The challenge for the Company undertaking the research was to develop capability in “exploration” whilst retaining the ability to maintain “exploitation”; enabling a degree of “ambidexterity” – being able

to sustain both kinds of innovation organization under the same business roof – as opposed to spinning off or setting up elsewhere (Birkinshaw and Gibson, 2004). This paper describes an attempt to develop such ambidextrous capability within this mature engineering business, and the results obtained. The focus is particularly on the development and shifts in the organizational culture – the underlying pattern of shared beliefs and values which shape behaviour and which make up “the way we do things around here”.

### Organization culture and innovation management

Cultural enablers and inhibitors have an effect on the ability of a business to be innovative, in terms of new product development (Jassawalla and Sashittal, 2002; Tushman and O’Reilly III, 1996). Incremental innovation usually emphasizes cost or feature improvements in existing products or services and largely depends on exploitation competencies. In contrast radical innovation concerns the development of new business or product lines, based on new ideas or technologies or substantial cost reductions that transform the economics of a business and require exploration competencies (Benner and Tushman, 2003). Where incremental innovations in new product introduction appear to be dependent on traditional management structures and processes (Ettlie et al., 1984), radical innovation requires a response that goes beyond the “steady-state” approach to managing innovation (McDermott and O’Connor, 2002). Radical innovation is often high-risk and potentially high-return, and therefore does not respond well to the management practices applied to incremental innovation activities (McDermott and O’Connor, 2002). For radical product innovation the emphasis is on dramatic departures from existing products or their logical extensions (Veryzer, 1998).

Although there are many dimensions that influence both incremental and radical innovation, for example, knowledge management, national systems, and labour markets; it is generally agreed that organizational culture is a significant influence on the propensity of an organization towards innovation (Tidd et al., 2001). There are many definitions of organizational culture, but the phrase “the way we do things around here” epitomizes what influence culture has on individuals’ behaviour (Drennan, 1992). Whilst there is disagreement about how to best organize for radical innovation, most managers agree it is an uncertain process when compared to incremental improvement – an on-going process with a systematic approach to change (Humble and Jones, 1989).

### Framework to understand innovation culture

The framework used for understanding innovation culture is Schein’s model (1984). He suggests that culture is a pattern of underlying assumptions that have been evolved, discovered or developed by a given group as it learns to cope with its problems of external adaptation and internal integration. His model exists at three levels. (1) Artefacts – the visible organizational structures and processes; (2) Values – the principles, goals and standards held to have intrinsic worth; (3) Underlying assumptions – the most invisible level of the model. These assumptions are taken for granted beliefs and habits of perception, thought and feeling that are rarely made explicit. Schein’s view focuses on what artefacts and values reveal about underlying assumptions.

A second complementary framework is that of organizational archetypes (Greenwood and Hinings, 1993). An archetype is defined in terms of two general statements. A holistic perspective that organizational structures and management systems are best understood by analysis of overall patterns rather than by analysis of narrowly drawn sets of organizational properties, and patterns that are a function of the ideas, beliefs and values that underpin and are embodied in organizational structures and systems. An archetype is thus a set of structures and systems that reflects a single interpretative scheme. Greenwood and Hinings suggest that structures and systems are not neutral, but include, knowingly or unknowingly, aspirations, intentions, and purposes. These two perspectives can be applied to examine the innovation culture (McLaughlin et al., 2008).

### The Research

The Company is an autonomous organization which is part of a UK based engineering group. It designed, manufactured, marketed and supported a range of quality measurement equipment world-wide.

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A grounded approach (Glaser and Strauss, 1967; Partington, 2002) to the research helped the data to emerge, and was developed and refined over a number of interactions with the new product development (NPD) team in a highly participative manner (Reason and Bradbury, 2001; Coughlan and Coughlan, 2002). The NPD team involved with the research comprised 14 development engineers who had length of service ranging from 2 to over 30 years. Organization culture characteristics were identified using an “issue” focus (Sackmann, 1991). This allowed the team members to consolidate their innovation stories and accounts around a specific action or event. Cognitive maps (Eden, 1988; Langfield-Smith, 1992; Swan, 1997) showing aspects of organizational culture influencing radical product innovation were developed and refined in follow up interviews with each member of the NPD team. These maps were individually validated and conflated into a single collectively validated map to represent the team’s collective cognition. Interview data were analysed and coded using theme based content analysis to show emerging themes and aspects of organizational culture that influenced radical product innovation. To triangulate the findings, established assessment tools, OCAI – Organization Culture Assessment Instrument (Cameron and Quinn, 1999), and KEYS – Creative Climate Assessment Tool (Amabile et al., 1996), were used to gauge the extant NPD team culture and its visible and audible behaviour patterns - what Schein described as the level of artefacts (Ekvall, 1996). Based on the emerging themes, Greenwood and Hinings concept of archetypes was deployed to conceptualize a model of incremental and radical as ideal types of an innovation culture. Finally the NPD team assessed itself to gauge its proximity to the “ideal” radical innovation culture in this model, using a Likert scale from 1 (least similar) to 10 (most similar). These areas of assessment are represented graphically in Figure 1 based on Schein’s model.

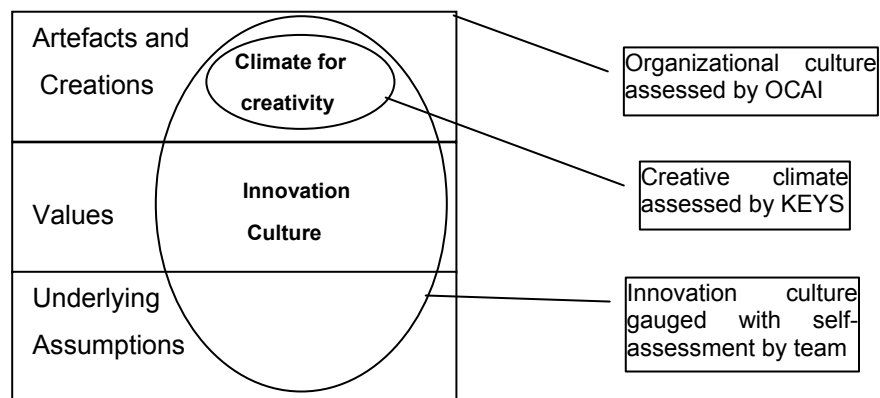


Figure 1 Culture and climate assessments based on Schein’s model

## Findings

The interviews with the NPD team members revealed nine key emerging themes that represent aspects of innovation culture influencing radical innovation.

1. Freedom/Latitude – relates to the opportunity to take autonomous action.
2. Attitude to Risk – relates to the attitude within the team to taking risks.
3. Growth/Development – relates to the development team gaining knowledge and experience, and exploration of potential solutions.
4. External confidence – relates to the team’s view about how they are perceived by company members who are outside the development team, in particular the top management.
5. Internal confidence – relates to the confidence the team have in their own capability to produce solutions that are radical.
6. External perspective – relates to links to outside agencies and organizations that influence the radical innovation capability of the team.

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7. Clear objectives – relates to the concept of having a clear and well defined objective for the development project and having an unchanging target during the time the development project is active.
8. Team constitution – relates to the nature, skill-set and composition of the team members.
9. Company infrastructure – relates to the infrastructure of the company around the development team, the resources made available to the team and the management style in which the team operate.

The OCAI analysis indicated an organizational culture that was perceived to be in line with a “do better” culture. The team members preferred culture was one that was highly scored in aspects that supported radical innovation. KEYS assessed climate based on six dimensions. Challenging Work – challenging tasks and important projects; Freedom - autonomy concerning the means but not necessarily the ends; Resources - time and money; Work Group Support - members share excitement and help team-mates; Supervisory Encouragement - encouraging the work of the team and its members; and Organizational Support – from the whole organization. The results from the first use of KEYS showed a very low climate for creativity. All dimensions scored low in comparison to other organizations.

### Interventions

The results of the assessments indicated areas of inadequacy with respect to a radical innovation culture. Companies that have been successful with radical innovation demonstrate strong leadership to and commitment from the organization for this type of activity. A plan of interventions was developed to foster aspects of a radical innovation culture in the Company Development Team. The intervention plan was built on interventions identified from empirical examples that included BMW (Radhika, 2003), Hewlett Packard (Christensen, 2003), Mattel (Zacharias, 2004), 3M (Gayatri, 2004), Harley Davidson (Sarvani, 2004), UK companies that participated in a discontinuous innovation forum and the research findings. The research conceived a series of linked interventions suitable for nudging the innovation culture to be more supportive of radical innovation. In conjunction with the NPD team, seven interventions to develop a radical innovation were developed (McLaughlin, 2006).

1. Team membership modified to add in “do-different” skills and attitudes.
2. Idea/knowledge gathering and sharing system
3. Encourage and facilitate input from external sources
4. Idea gathering as a formal process
5. New product opportunity areas be identified
6. Show and tell presentations
7. Develop a “Do different” project

### Outcome

The interventions were implemented over a four to five year period. At the end of this period, the climate and culture assessments were deployed again.

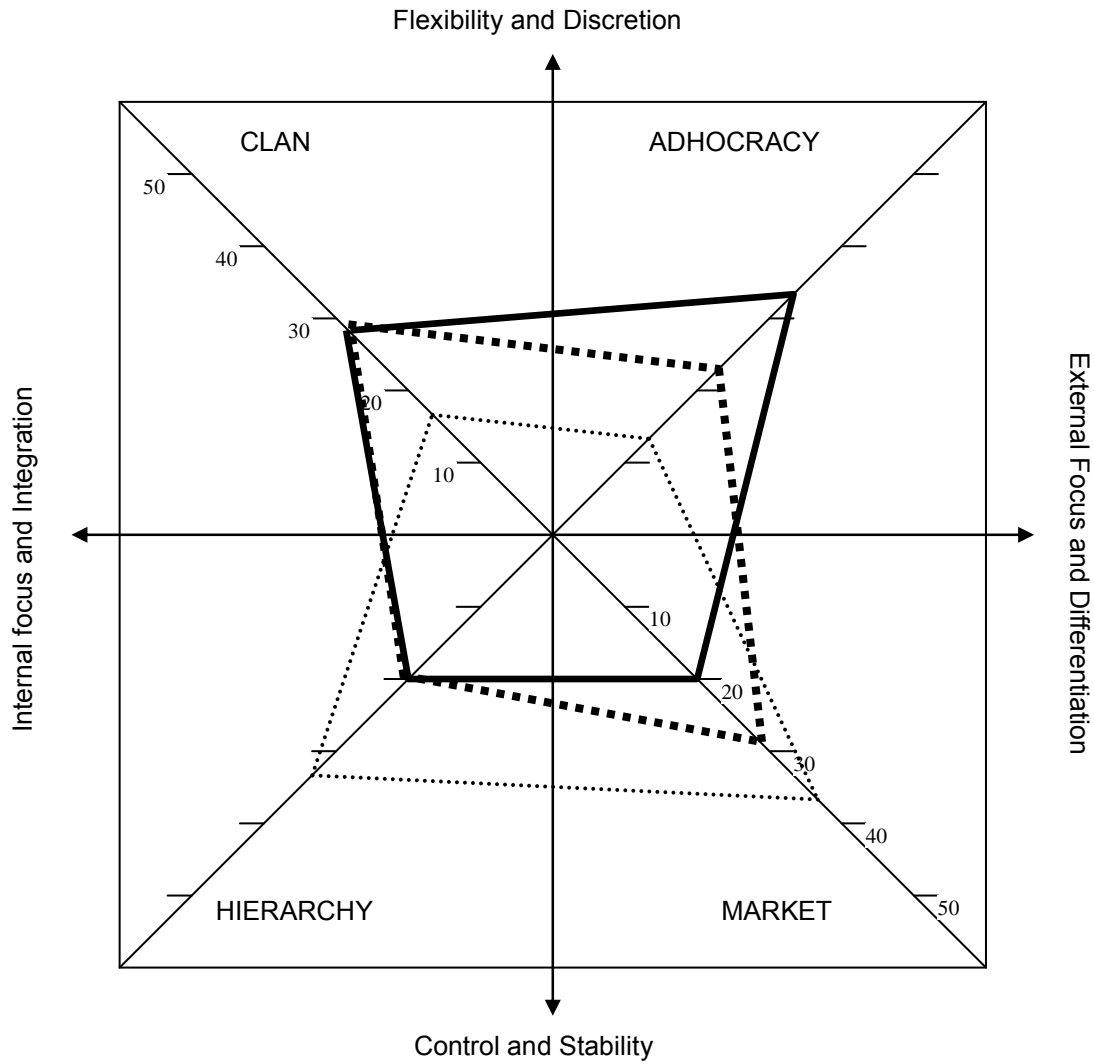
OCAI (Cameron and Quinn, 1999) indicated a move towards a more innovative (ADHOCRACY) culture. The desired position remained substantially unchanged (Figure 2).

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### OCAI Results

Actual and Desired position Before v Actual position After

Actual position Before (.....)  
 Desired position Before (———)  
 Actual position After (●●●●)



	Before	After
<b>ACTUAL</b>		
CLAN	16	28
ADHOCRACY	15	23
MARKET	35	29
HIERARCHY	33	20
<b>PREFERRED</b>		
CLAN	28	28
ADHOCRACY	32	32
MARKET	21	22
HIERARCHY	20	18

Figure 2 Before and After scoring on OCAI



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The climate for creativity assessment KEYS (Amabile et al., 1996), showed a significant increase on all the dimensions with significant improvements on five (Figure 3).

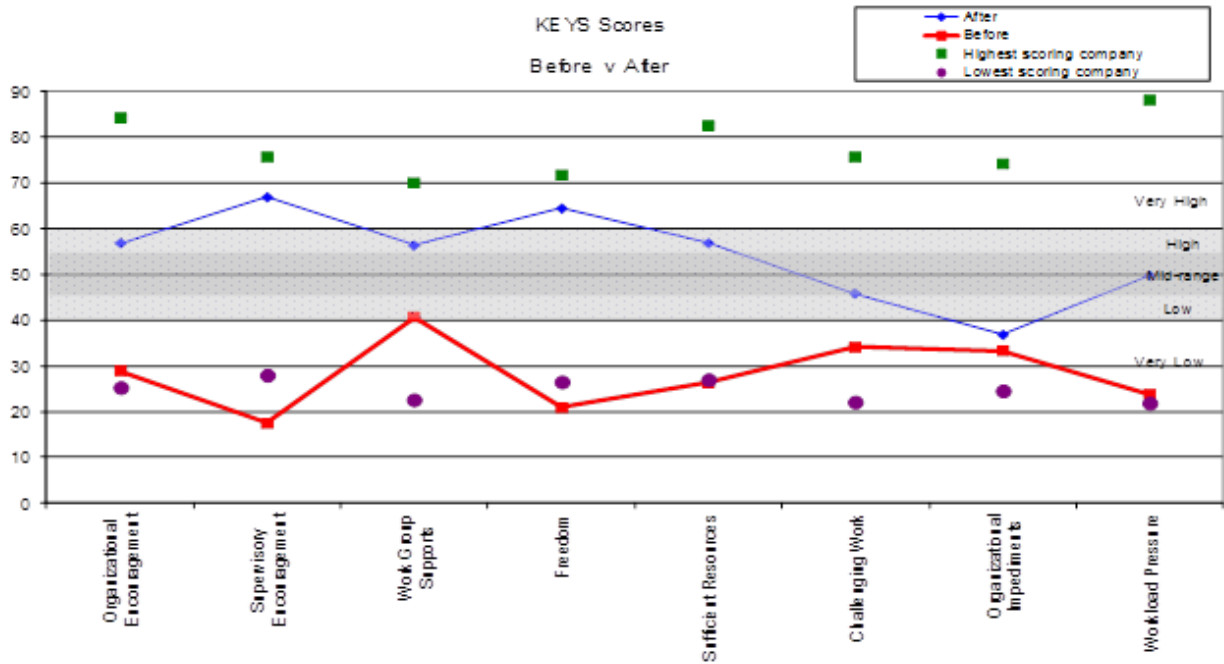


Figure 3 Before and After scoring on KEYS

This is supported by the improvement shown in the assessment of proximity to the “ideal” radical innovation culture. The before and after scores display improvements on all the dimensions (Figure 4).

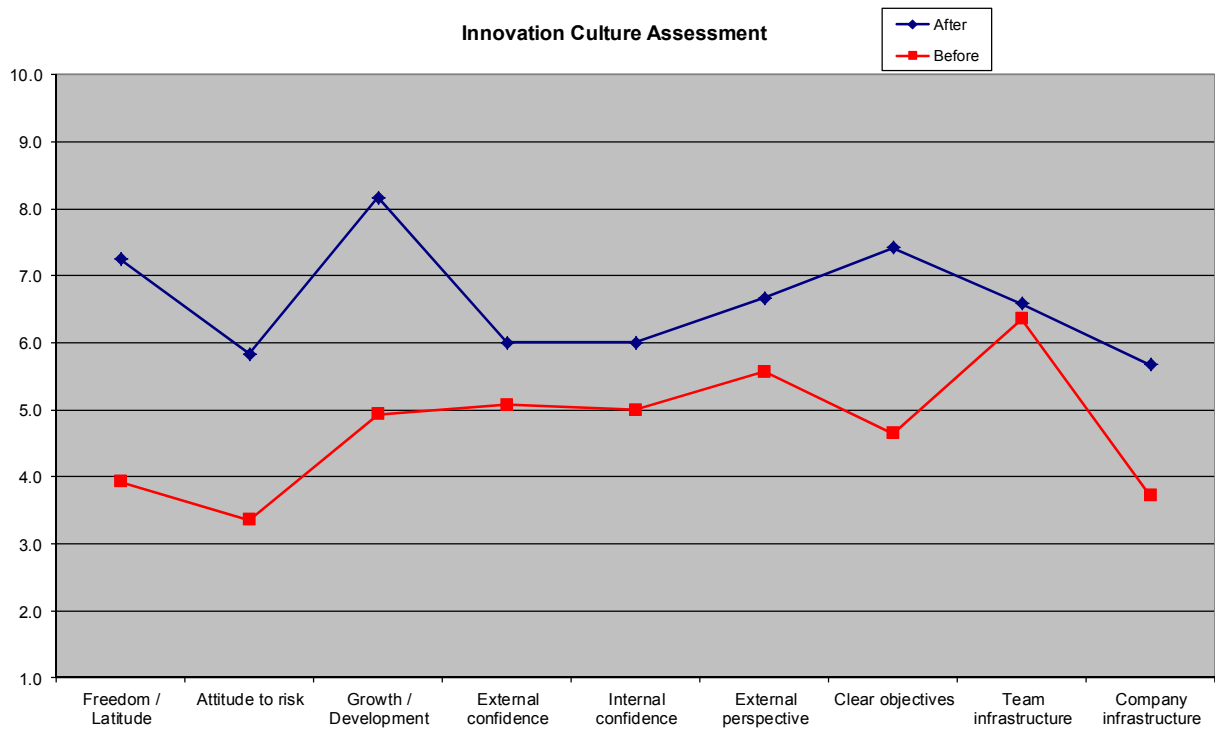


Figure 4 Before and After scoring on Innovation Culture

From a company perspective, the interventions launched a change in the NPD team that allowed them to create a series of radical innovations. This is supported by the increase in the number of patent applications increasing from 0 during the previous 24 months to an average of 5 at the point the “after” culture and climate assessments were made. Patent application indicates R&D intensity and is considered to be the single most common indicator of a company’s propensity to undertake radical innovation (Ettlie, 2000). During the same period, the number of new products launched during the preceding 24 months increased from 0 to 18.

### Conclusions

The opportunity to conduct research in a “live” NPD team allowed the development of an organization culture that was more predisposed towards radical innovation than prior to the project commencing. Gauging the culture and climate for creativity indicated an improvement over the duration of the project. This improvement is borne out by a tangible increase in patent applications and an overall increase in the number of new products launched. Whilst the interventions were conceived for the Company hosting the research, their applicability to other mature SME businesses can be considered with some adaptation.

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## The Role of Connections and Users' Involvement in Designing Sustainable and Longer Lasting Artefacts

Massimo Micocci

Research fellow

Politecnico di Milano - Chemistry, Material and Chemical

Engineering Department "Giulio Natta"

Piazza L. da Vinci, 32 - 20133 Milano

Italy

Giuseppe Salvia

Ph.D. Candidate

Politecnico di Milano - Chemistry, Material and Chemical

Engineering Department "Giulio Natta"

Piazza L. da Vinci, 32 - 20133 Milano

Italy

Francesca Ostuzzi

Research fellow

Politecnico di Milano - Chemistry, Material and Chemical

Engineering Department "Giulio Natta"

Piazza L. da Vinci, 32 - 20133 Milano

Italy

Valentina Rognoli

Assistant Professor

Politecnico di Milano - Chemistry, Material and Chemical

Engineering Department "Giulio Natta"

Piazza L. da Vinci, 32 - 20133 Milano

Italy

Marinella Levi

Full Professor, Materials Science and Technology

Politecnico di Milano - Chemistry, Material and Chemical

Engineering Department "Giulio Natta"

Piazza L. da Vinci, 32 - 20133 Milano

Italy

### Abstract

Environmental consciousness is attaining a new value in design practice. The following paper investigates the potential contribution of a new design approach to increase the environmental benefits by re-use practices.

This research describes the role of connections as actuators of empathic relationship between artefacts and the user. It outlines paths for designers to foster and support the involvement of users in waste-reduction concerns through the promotion of the “R”-strategies (Council Directive 75/442/CEE); active participation of people is needed to gain sustainable advantages for products re-use, repair and repurpose with the aim of deferring the products end-of-life (Chapman 2005).

The research defines four “communicative scenarios” between a *user* and an *object* through the analysis of about 150 significant products. This study further contributes to Design for Re-use by gathering 22 joining systems with a higher potential for interaction in each scenario. Eventually a synoptic table is shown to help designers with the presented approach for longer lasting products.

### 1.0 Introduction: sustainable design by reusing

This research investigates the role of “connections” for waste reduction by reusing, the most auspicated strategy together with prevention (Council Directive 75/442/CEE). The general goal is to address the Reuse strategy as potential design practice for longer-lasting and durable artefacts, thus meeting the growing need of promoting sustainable patterns of production and consumption (Gagnon, Leduc & Savard 2012), (Rockström et al. 2009), (Thackara 2006), (Chapman 2007), (Cooper 2002). In fact Reusing has been demonstrated to foster creative practices promoting acts of appropriation (Maestri, Wakkary 2011) and possibly behavioural change required to promote sustainable design (Tromp, Hekkert, Verbeek 2011), (Bhamra et al. 2008).

In the following paper the reusing strategy is presented by exploiting the opportunities of joining systems and how users can interact with. As a result, a classification of design-led joining systems emerged to trigger a novel approach to reusing as an advantageous occasion fitting a variety of changing contexts and needs.

#### 1.1 Communicative scenarios and Connections

The research took into consideration a valuable concept for “connection” from the Topological Psychology, by the psychologist Kurt Lewin (Lewin 1936), to establish a part-whole bond in human relationships. According to this theory every object or person involved in a mutual interaction with the other could be defined as a *region* while both are considered the *field of interaction* when such bonds exist. Regarding the scope of this research artefacts and their users are referred to as regions among which connections take place.

Attilio Marcolli (Marcolli 1971) starts from Lewin’s theory to focus on the dynamics specifically intended for relationships between products and users and the implications of these connections in different design contexts. Inferring from this studies, joining systems are equal to the whole objects in terms of the semiotic contribution of “being a sign”, and therefore we assume that joining could foster emotional connection alike, if efforts are conveyed to a purposely driven design process.

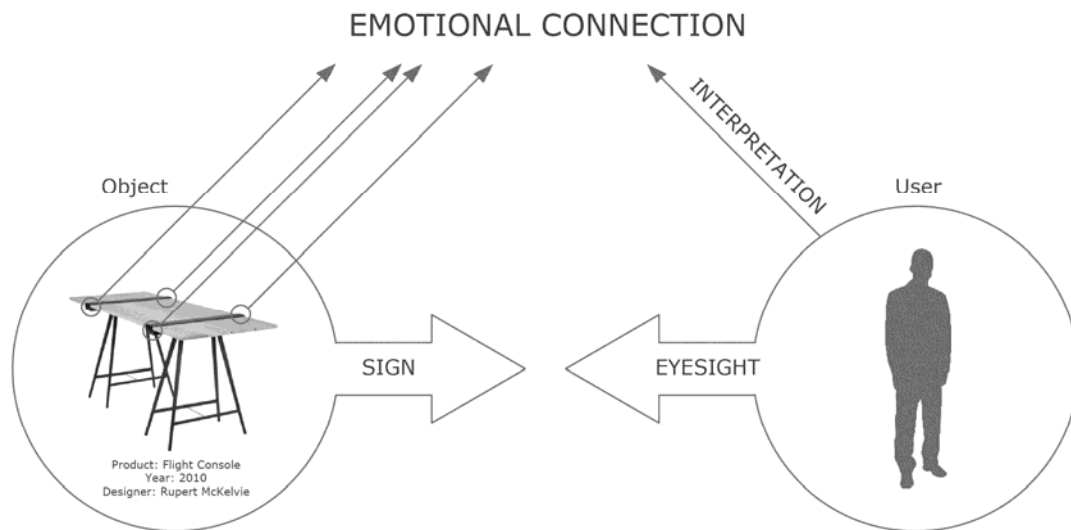


Figure 1. From a Semiotic point of view (Peirce 1931-1958), the features the object has and its structural joints return a sign that the user can interpret. These features, while being the structural link between different regions of the same product, bring about an emotional bond and a behavioral response to.

Accordingly, any kind of objects can be assumed by designers as a set of regions and connections with other regions and users. Crossing the single regions, connections allow the communication between the components thus providing the user with the idea of the system's primary function. Connections accomplish two main scopes (Marcolli 1971) in the Object/ User relationship (O-U):

- *locomotion*: the ability to move from one place to another;
- *communication*: the reaction that is triggered at a distance.

These are assumed of fundamental importance for designers to consider since the earlier stages of the designing process to foster the reuse of object over time. The classification of possible interaction experiences for O-U called "Communicative scenarios" (Marcolli 1971), is used to describe joining systems and the paper aims at briefly describing them to argue about their contribution to sustainable design. Communicative scenarios are defined by two main axes that for the scopes of this research are:

- material connection (connection reversible or not);
- interaction reported (how and how much the user can interact with).

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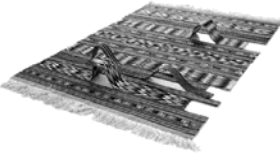

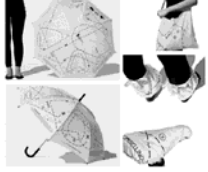
	 <p>The relationship between O and U, even if desired or when O and U are located within the same boundaries, may not exist because they are separated by physical or conceptual impediments that divide the main set into two regions that can not communicate.</p>	 <p>O and U communicate because of a mutual relationship for which a communication path is established. Such path is a small inner region within the main region. Some products are specifically designed to create a reciprocal exchange with the user and to make so that materials and functions are easily upgradable.</p>	 <p>The tendency O shows to communicate with U generates a field of forces from O to U.</p>	 <p>Intermediate regions form an often tortuous communication path between O and U. These steps tend to make the central region a more undefined one.</p>
goals	<p><b>Connection prevention</b> preserve the object immutability over time</p>  <p>Product: Fossili Moderni Year: 2005 Designer: Massimiliano Adami</p>	<p><b>Communication path</b> encourage interaction object-user and the possible evolution of the object over time</p>  <p>Product: Nule Fiamma Year: 2007 Designer: Paolo Ulian</p>	<p><b>Generation of forces</b> to suggest the proper use and the eventual reuse; disclose the potential connection</p>  <p>Product: Stiller Gefahrte Year: 2009 Designer: David Olschewski</p>	<p><b>Mediated access</b> mediating the interaction and product accessibility through intermediate steps and tips</p>  <p>Product: Ombrello The Reusable Year: 2009 Designer: Barbara Civillini, Alice Bertola</p>

Figure 2. Communicative Scenarios: descriptions and goals.

In the first scenario, “Communication prevention”, user and object coexist in the same region. Although object’s performances are not compromised, no structural intrusion caused by the user is allowed (if not previously foreseen by the designer).

The second scenario, “Communication path”, considers the inner region as a “possibility to take place”. The user is allowed to perform on and edit the structure of the object that should have been designed for such purpose.

The third scenario, “Generation of forces”, gathers connections that set objects in order to provide signals and messages to the user similarly to the “affordance” theory by Gibson (Gibson 1977). In this case the design of shapes and features appearing or reacting similarly to other objects, even if the result is different (Morrison J. in Fukasawa 2007) and may support the interpretation of the proper use of the artefact.

The fourth scenario, “Mediated access”, relates to objects in which interaction O-U is not necessarily facilitated. In some cases the way how object and user interact is mediated by constraints that make user’s action particularly challenging, so that users can be guided by design-features to support even laypeople in reusing and maintaining tasks.

## 2.0 Design Investigation: 150 study case

The empirical part of this research analysed relevant existing cases valorising joining solutions as promoters of reusing practices.

To this purpose, existing design-led artefacts<sup>1</sup> have been collected and analysed because of the opportunity offered for both user’s participation in reusing process and behavioural change, as envisaged by the authors. The boundaries for this step of the investigation have been extended to the limits of apparently unconventional or not acknowledged joining solution for product design discipline (Bralla 1999). Qualitative criteria followed for the selection were based on the value derived by: valorising connections, re-functionalising discarded objects, dematerializing involving user in design process, and fostering design innovation.

<sup>1</sup> The collection of relevant cases has been carried on both by personal authors’ knowledge and monitoring the main international industrial design blogs for a period of 5 months. These blogs are:

[www.designboom.com](http://www.designboom.com), [www.dezeen.com](http://www.dezeen.com), [www.designspotter.com](http://www.designspotter.com), [www.redesignndesign.org](http://www.redesignndesign.org), [www.superuse.org](http://www.superuse.org), [www.core77.com](http://www.core77.com), [www.recyclart.org](http://www.recyclart.org), [www.designspongeonline.com](http://www.designspongeonline.com), [www.marraiafura.com](http://www.marraiafura.com), [www.psfk.com](http://www.psfk.com), [www.mocoloco.com](http://www.mocoloco.com), [www.artecnicainc.com](http://www.artecnicainc.com), [www.design-klub.com](http://www.design-klub.com), [www.treehugger.com](http://www.treehugger.com)



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communicative scenario	possible	very possible	certain	connections
	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	
	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	

Figure 3. Table for case study selection.

The resulting selection of 150 products has been later further analysed (Figure 3) to infer the Communicative Scenario each of them opens, hypothesising a level for its chance to happen, i.e. possible, very possible, and certain).<sup>2</sup>

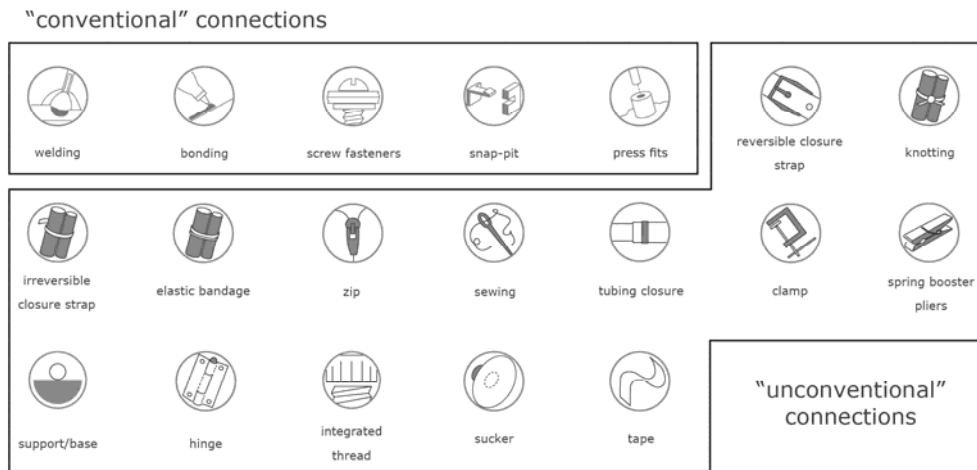


Figure 4. Connections disclosed.

On the basis of the *life cycle thinking* approach (Vezzoli, Manzini 2008),(Sy & Mascle 2011) the analysed products have been subsequently classified according to the specific strategy for lifespan elongation, namely Repairing, Reusing, and Repurposing.

<sup>2</sup> Inspired by the method of classification of VDI (Verein Deutscher Ingenieure), using qualitative tables to prevent products recyclability.

2.1 Repairing

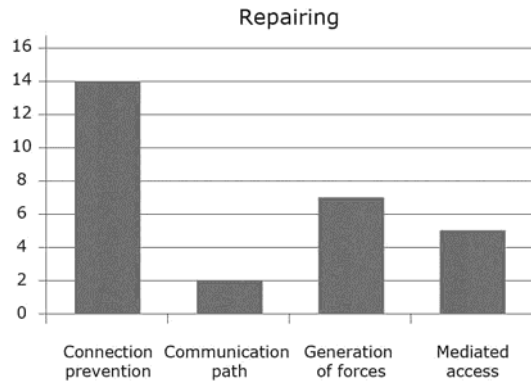


Figure 5 Repairing approach

The Repairing category includes artefacts intended for connections that generate aesthetically pleasant and fascinating solutions, typically for their features of ‘imperfection’. Imperfection on artefacts have been envisaged as opportunities to generate uniqueness since a long time (Papanek 1995) and more recently design strategies promoting the valorisation of imperfect features have been interpreted to prolong emotional attachment (Salvia, Ostuzzi, Rognoli, Levi 2010). This approach appears to be stimulating and challenging for design professional considering that aesthetical and emotional appreciation of the repair intervention allows designers to experiment new solutions in contrast with the fixity of standardized shapes (Mugge, Schoormans & Schifferstein 2009). The resulting strategies reported in the empirical step mainly address lifespan-prolongation by preventing further occasions for damages to the object so that incommunicability between object and user is usually pursued. For this reason the “Connection prevention” scenario is mainly observed in this approach: 14 artefacts including glued fragments of broken vases firmly tighten chair parts, stable interlocking of shelves. Furthermore, a few cases classified under the “Generation of forces” scenario have been observed (7 in total). In this case, designers proved to accept product defects, working on the aesthetics of the reparability, e.g. malleable materials to repair or optimize, wads of wool used for instant and permanent repair of many tissues and ripped holes. The “Mediated access” scenario has been used in 5 cases to help user in repair process, e.g. elastic bandage to cover broken shelves and universal rings able to fix old holes in wooden furniture.

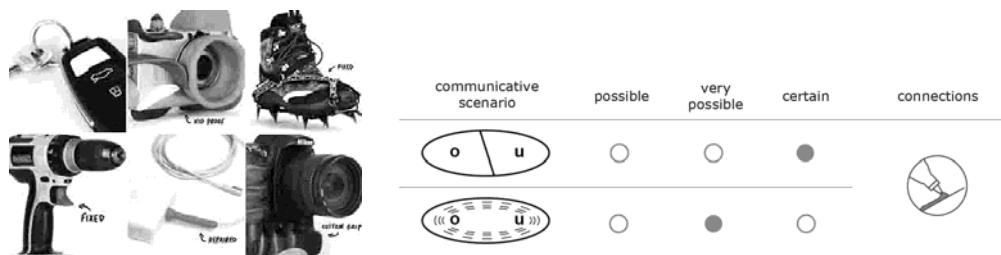


Figure 6. Jane Ní Dhulchaointigh designed “Sugru” (2010), air-curing rubber that creates a fatal connection between the bonded parts by helping the subject to maintain its primary function or the new desired configuration.

2.2 Reusing

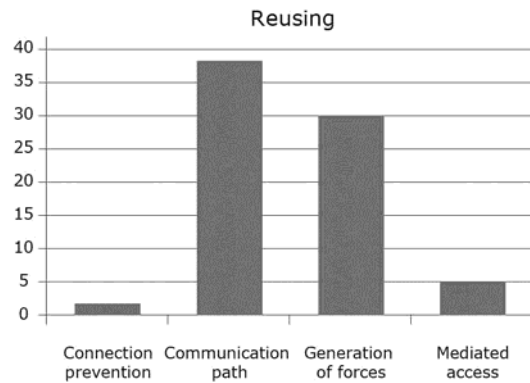


Figure 7 Reusing approach

Our current production system filters out the necessary information that should come to the designer and consumer (Walker 2006). Progress through sustainability requires a transformation of attitudes, and the work of Buber (Buber 1996) suggests that this change should lead to the idea of *relationship* between product and user. To design such objects requires responsible acknowledgements of their transience, and an approach that facilitates the eventual reapplication of their parts, or their reintegration in the world (Walker 2006).

In the second category of collected artefacts, we defined “Valid” Reuse (Villa 2005) an approach where objects were considered by their residual and secondary qualities present in the geometry, form, material and structural connections. In this view discarded items are valorised for the still (even unknown by user) profitable embedded qualities. Accordingly, repairing task by reusing represent participatory and collaborative process triggered by designers and finalized by users. In this case the main contribution by design is the facilitation of the reuse process intended for object evolution and user’s individual identity.

Here, artefacts are designed to communicate their capability to grow and evolve, mostly generating scenarios of "Communication path" and "Generation of forces", that also constitutes the most conspicuous cases out of the collected ones (38 and 30 respectively). Connections in this category show high adaptability to different substrates, functions and so life cycles in order to cope with the unpredictability of products, thus stimulating the designing of most of the mentioned unconventional connections (57 out of 68).

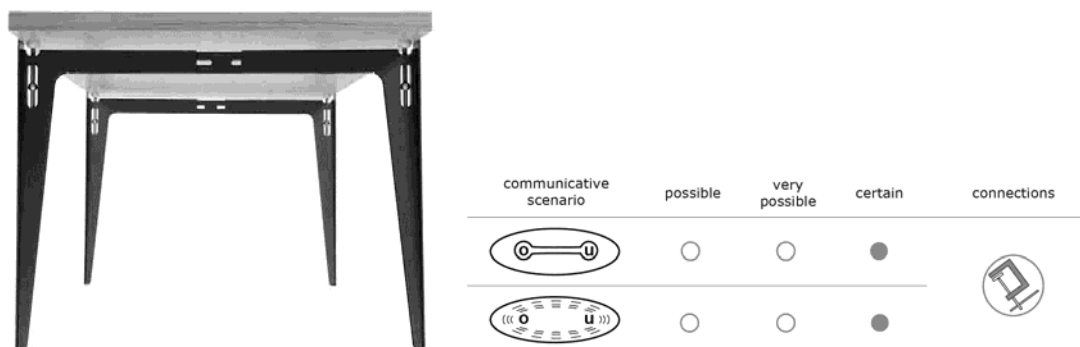


Figure 8. Philippe Nigro in "Piètement Universel" (2009) proposes a universal base by using highly one adaptable connection, a *clamp*, creating a strong communication impact.

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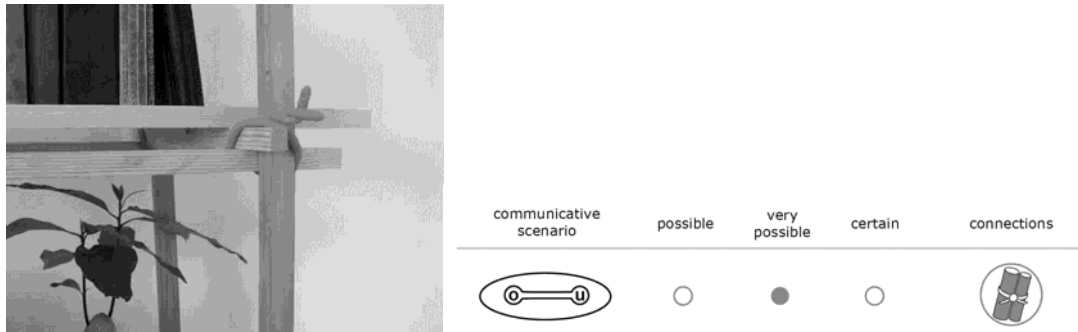


Figure 9. In “Flexible Joinery” Tal Mor & Shlomi Azuali (2011) use a *knotting* as main structural point to obtain a bookcase and to join together discarded wood boards.

### 2.3 Repurposing

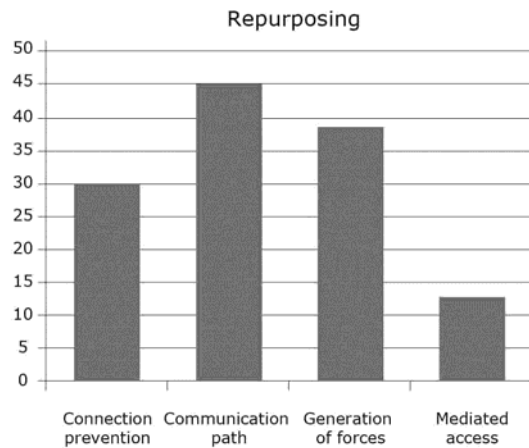


Figure 10. Repurposing approach

The third category of “Revived Object”<sup>3</sup> includes discarded artefacts brought to a second life by joining design-driven solutions. In this category manifold typologies of interaction between users and objects are possible. There is a considerable willingness to make an object alive by updating its configuration through the continuous user involvement (Scenarios of Communication path, and Generation of forces) or to extend the product over time, pursuing the preservation of the communicative experience so obtained (Connection prevention).

Similarly to the first Repairing approach, conventional joining solutions are here recurrent in order to limit and possibly prevent the interaction of users with objects parts. The trustworthiness of a conventional joint as a gluing, is often preferred to systems not totally verified, especially when a designer wants to obtain stability and structural value for a product. “Generation of forces” scenario is solely constituted by unconventional systems (38 examples in total). This demonstrate the need to adapt products to customizing tasks relying on user’s inclination and ability for interpreting and elaborating a personalized solution e.g. lamp structures made by threaded pipes, modular bookshelves joint together with reversible closure strap and seat of a chair made by knotting old clothes. In “Communication path” scenario (43 examples in total) we observed the desire of designers to start a process of cultural knowledge of the objects which allows the user to be more conscious about the potentiality of products.

<sup>3</sup> Locution borrowed from Morozzi Cristina 1998, Oggetti risorti, quando i rifiuti prendono forma, Costa & Nolan, Milano.

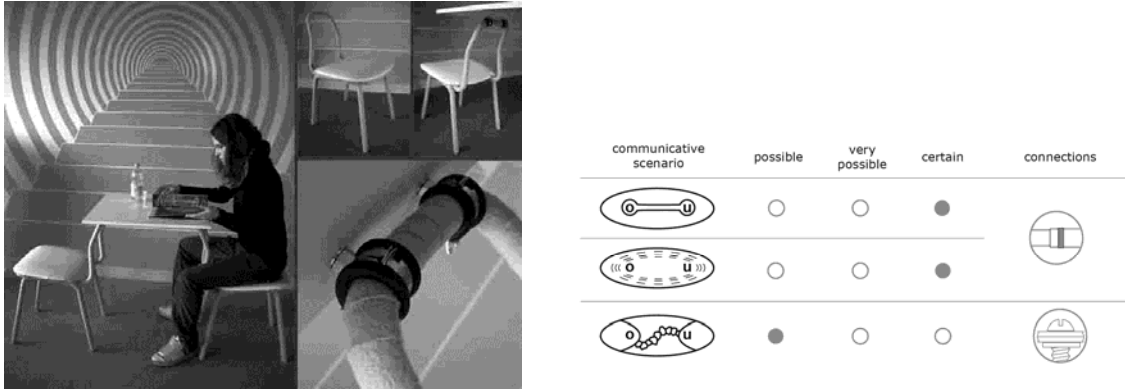


Figure 11 MacsDesign (2009) through a reversible *tubing closure* connection on the backrest of a chair experiment new way to upgrade an object in aesthetic and function.

### 3.0 Conclusion

The research addresses the potential for connecting systems to prolong products lifespan and a systematic approach for critical analysis and interpretation of existing design-led joining panorama has been pursued. As an output of the research, we propose an approach to reusable artifacts as a source for further inspiration, insights and development to designers and researchers.

To this purpose, Communicative Scenarios emerging from reusing experience are here represented and briefly described to provide basic inferring for future developments.

*Connection prevention:* when using unconventional connections this scenario could be reach in a more flexible way. Indeed it strictly depends on the execution pattern of the connection. The “knotting” can manifest separation between object and user only if performed properly by avoiding undue loss of parts; as well as the “irreversible closure strap” it forces the user to intervene with specific tools and open up communication with the object.

*Communication path:* this scenario can be achieved in various ways, mainly related to the reversibility of the connection. Many of these systems allow adaptability to various substrates, such as “clamps”, “elastic bandage” and “spring booster pliers” in order to easily start a process of customize the desired final solution.

*Generation of forces:* the connections that help to generate communication forces are roughly the same that generate the “Communication Path”. Their goal is to communicate the product’s tendency to be modified by the user. Designer could foster this scenario through connections as “tape” and “sewing” that reveal their presence and encourage an appropriate intervention.

*Mediated access:* the level of communication between object and user can be regulating by referring to the user’s skills to interact with the object. Thus many connections must create a dialogue also with unskilled users through intermediate steps. The power of design connections is that designer is enabled to complicate the communication or simplified it only by modeling the several steps that divide the object and the user.

Insights from this research and paper have been qualitatively synthetized in a synoptic chart (Figure 11) to visualize the afore-described Communicative Scenarios in relation to the three approaches for longer-lasting reusable products. Each joining solution could be interpreted according to several Communication Scenarios or approaches, although 1:1 link between connection and user reaction has been preferred for explicative purposes.

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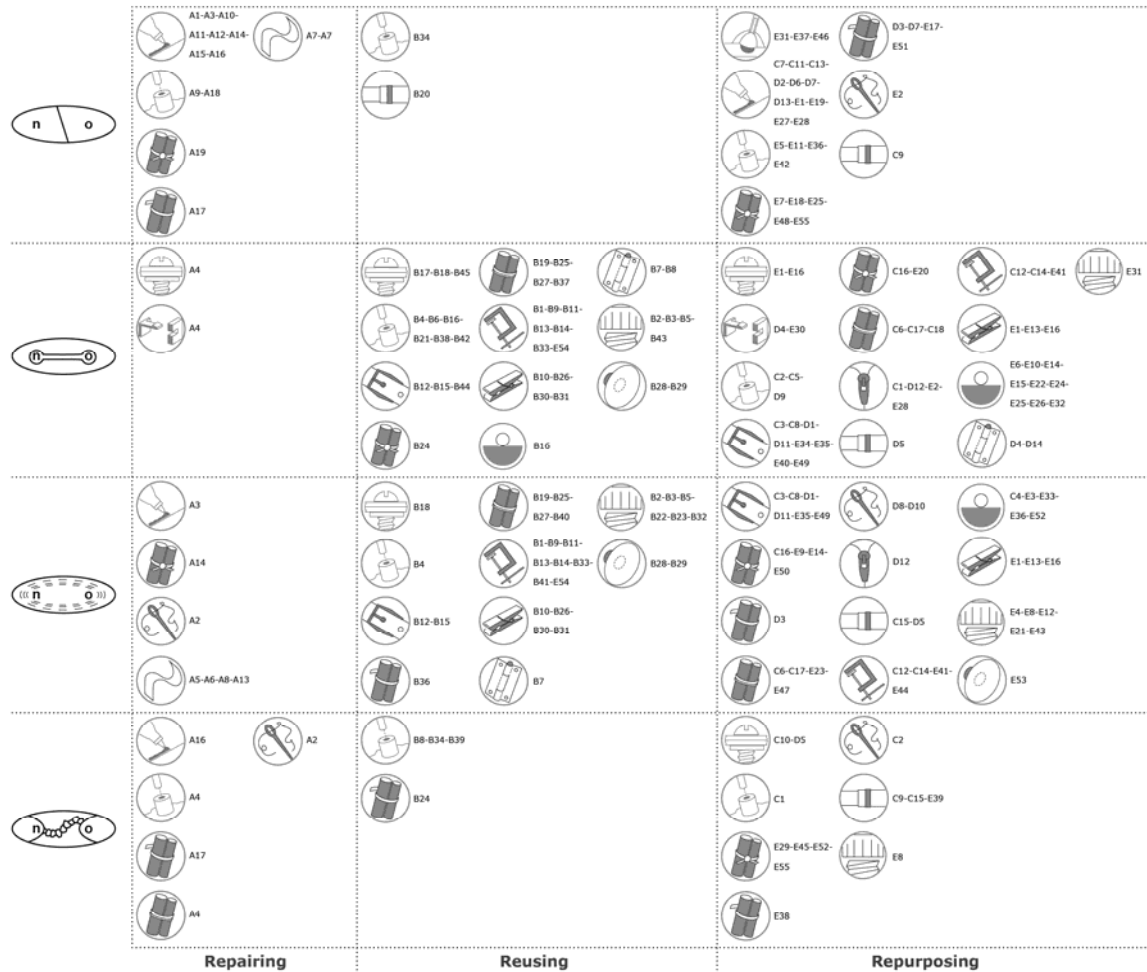


Figure 12. Synoptic table Communicative Scenarios (Y axis) / lifespan elongation approaches (X axis)/ connections. The codes near each connection mean the number of case study cataloguing

In conclusion of this paper, future development are auspicated concerning namely the extension of the analysis to a wider selection of products, the involvement of stakeholders for the actual testing phase of this research inferring, participatory platforms for collecting and visualizing joining solutions for longer longer-lasting products.

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## Building Materials With Low Embodied Energy in Their Life-Cycle

Martino Milardi

Researcher,

Dipartimento Architettura e Territorio - DARTE

Università degli Studi Mediterranea di Reggio Calabria

Via Melissari, 1

89124 Reggio Calabria

Italy

### Abstract

Making decisions about energy sources remains one of the greatest challenges in addressing climate change. Just as we can have a breakthrough in technology, we can have a breakthrough in approaches to energy decision-making. There is already a wealth of information available to policy-makers and other decision-makers to help them make better choices about energy production and usage, as well as research that demonstrates how factors other than economics can influence decision-making at individual, social and institutional levels. Research on energy decision-making to date has tended to focus on theory, on analysis of small case studies, or analysis of statistical data without a clear understanding of the motivations behind the statistics. This paper highlights the need to incorporate our existing knowledge into our policies, analysis of energy and technology options, and actions as a society; and the need to improve our knowledge of decision-making going forward

### Premise: the energy of the existing building stock

In the general context of the evaluation of the impact of the building sector on the mechanisms of environmental systems both at a local scale and from a global perspective, energy parameters are a fundamental factor. These factors constitute a crucial indicator for a quantitative evaluation of the environmental compatibility of a building product and/or technical system (Spiekman 2010). In this research, the studies focus on the building envelope systems and consider:

- climatic and microclimatic characteristics of the intervention context (Southern Italy) ;
- thermophysical behaviour of used building materials and components;
- quantity of energy used in the production of materials and components.

The purpose of the study is to establish a Decision-Making Support System for intervention on existing buildings.

Since in Italy, 34% of current building interventions are directed towards existing building stock, the field of inquiry covers public residential building stock that requires energy retrofit interventions to restore performance to the levels established by current energy-saving regulations.

The objectives of the present research derive from the need to define a procedure for intervention in this sector and to apply this procedure to systems whose energy characteristics – from the production phase onwards - are in line with the need to guarantee interventions with low environmental impact.

The proposed model will consider the energy performance of an existing building organism using a series of parameters and indicators that are closely tied to the intervention context. From the results of the evaluation possible strategies of intervention and the relevant operative actions should emerge.

Studies which investigate the types and quantities of energy employed, identify embodied energy as a parameter for control, using it as a principal indicator in the most consolidated systems for the evaluation of energetic and environmental performance of production processes.



The quantification of embodied energy for any particular material is an inexact science. Consequently, the complexity of obtaining accurate figures from embodied energy calculations is very great (Dubreuil 1997).

In order to simplify the process, the present study has been conceived on the basis of protocol evaluation models, or models which refer to the decision-making code. More rigorous evaluations that may be translated into software and databases may be carried out at a later point.

The basic premise upon which the research procedure is construed is the undeniable complexity of the relevant scientific field. This complexity, which is often due both to the number of different sectors involved as well as to the particular qualities of significant elements, makes for a notable quantity of information which can act as an obstacle to a successful study. For this reason, the present study will refer to consolidated research practices which, in their rigorous definition of the objectives in the preliminary phase, provide a reliable guideline for the direction and development of the study.

### **Our Approach: the role and evaluation of embodied energy**

In recent years, the building and construction sector, as all others that are involved in the transformation dynamics of our planet, has undergone considerable changes. These changes to a great extent have been caused by the conceptual and operative consequences of themes regarding the sustainability of their actions.

In the context of international debate, consensus is commonly reached regarding the impact of the construction industry on the planet's carrying capacity, indicating how far materials are a determining factor in the increase of critical levels related to the said impact.

There is no doubt that the constantly increasing flows of energy required by production processes must now be considered as new "incorporated rates" which increase the environmental burden of any given product and which therefore constitute an additional quality to be taken into account in the decision-making procedure.

Furthermore, in the light of quite justified alarms regarding the high energy consumption of the building industry, it has become necessary to revise all related processes in order to contain the effects of this particular characteristic - from the quantity of material required to the energy needed for its transformation - in order to reconstruct the entire product lifecycle whilst keeping to the performance requirements and regulations required.

In this sense, studies which investigate the types and quantities of energy employed in order to obtain "one unit of product" identify *Energy Intensity* as a parameter for control, using it as a principal indicator in the most consolidated systems for the evaluation of energetic and environmental performance of production processes.

In particular, the principle factor for the understanding and evaluation of the quality, incidence and therefore the effects of energy intensity related to production processes and building materials is the value of *Embodied Energy* (Alcorn 1998).

Sustainable Development and Eco-Efficiency patterns have revealed how much activities connected to the building cycle, at both programming and operative stages (material acquisition, manufacturing, building, management, demolition, recycling, disposal), have a decisive impact on the resource calculation and on the planet's load capacity, in relationship to the waste produced by the cycle itself. Energy flow, which is converted and downgraded during building activity, can be divided into five categories:

1. energy necessary for material acquisition processes and relative transportation;
2. energy necessary for component production and manufacturing and relative transportation;
3. energy necessary for construction processes and relative transportation;
4. energy necessary for management and use of the constructed product;
5. energy flows of emissions, demolition, reclaim, reuse and recycling processes.

In addition to that used in building, the energy required for the use and management of finished constructions makes up about 50% of the energy consumption of the European Union; in this sector, low temperature applications account for 85% of the entire demand. The resulting environmental

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impact of this consumption is significant: the building sector is responsible for 33% (average value) of the total energy consumption of EU Member States, producing 30-40% of total CO<sub>2</sub> and CFC emissions.

This approach can be considered correct if one considers that the construction of a building uses materials and energy, variable in quantity and quality, which are necessary for the transformation and assembly of different elements.

In the light of this, one can consider *Intensity*, understood as *the quantity of a given resource, energetic or material, used to produce services or products*, closely connected to the *Resource* from the moment in which the *building product* begins to be built (Bringezu, Stiller, Schmidt-Bleek 1996). It is then possible to set indicators that can direct the investigation. These indicators relate to two associated aspects in the eco-efficiency sphere:

Material performance both in use and potential;  
Natural emissions during the material's life-cycle.

For the building sector this means that:

- Buildings should have a lesser impact upon the material stock of the planet (influence in the *Resource* area);
- Buildings must be “thermally” efficient, in order not to contribute to the increase of emissions provoked by primary energy consumption (influence in the *Emissions* area);
- Building cycle processes must control their performance regarding balance between acquired/transformed material and emissions produced in the cycle (influence in the *Resource* and *Emissions* areas).

In this way, the identification and evaluation of new and different performance characteristics of material would appear to influence the creation of specific eco-efficiency indicators in the building sector.

The approach to energy decision-making remains one of the greatest challenges in addressing climate change. Technology experts tell us that there are many energy efficiency technologies available today that are cost-effective and in line with current energy prices, but which are not yet being fully deployed. Our incomplete understanding of why such technologies may or may not be adopted is a prime example of the type of challenge involved in decision-making in the efforts to mitigate climate change.

The situation that has arisen, shows how the eco-efficiency theme includes three important problem areas, which involve some clear control lines, feasible in an “entire cycle”:

- *Resource* use (defined as groups: energy, soil, water, material)
- The *Intensity* of the energy and material of the same;
- the *Emissions* produced by the transformation processes.

Debate literature and the results of several studies, have always placed emphasis on how these three areas should be understood, and how they should be considered within the perspective of the *entire cycle*.

The various requirements go from the reduction of greenhouse gases produced by fossil fuel use, to the “drastic” reduction of resource use, to a minor waste of energy and material “per product and service unit”, to the increase of service intensity, to the product use and durability extension. A synthesis of these requirements can be represented by the WBCSD eco-efficiency concept definition studies: “... to improve their eco-efficiency the companies must: - reduce material intensity of goods and services, reduce toxic dispersions, increasing material recyclability, extend product durability, increase service intensity of goods and services (WBCSD 1999).

There is no doubt that the constantly increasing flows of energy required by production processes must now be considered as new “incorporated rates” which increase the environmental burden of any given product and which therefore constitute an additional element to be taken into account in the decision-making procedure.

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Therefore, studies which investigate the types and quantities of energy employed, identify *embodied energy* as a parameter for control, using it as a principal indicator in the most consolidated systems for the evaluation of energetic and environmental performance of production processes.

The quantification of embodied energy in any particular material is an inexact science, requiring a "long view" look at the entire life-cycle, and filled with a large number of potentially significant variables. Consequently, obtaining accurate figures for the evaluation tool through embodied energy calculations, is highly complex (Atkinson 1999).

The embodied energy value is the energy per unit necessary for:

- Quarrying the raw material;
- Transportation to the manufacturing unit;
- Manufacturing building material;
- Transportation of finished material to the distribution outlet.

The assessment of embodied energy considers the energy required to extract raw materials plus the energy used in primary and secondary manufacturing activities to provide a finished product. There is embodied energy in any processed product, from a pen to a building.

In order to reduce the complexity of the evaluation process, the present study has been conceived on the basis of protocol evaluation models or models which reference the decision-making code. Further and more rigorous evaluation of acquired data that may be translated into software and databases may be carried out at a later point (Baird, Alcorn, Haslam 1997).

Drawing on a critical reading of the premises and of the most significant results of state-of-the-art and regulatory references, the present study has defined a procedure for research which has developed in concordance with three phases: analytical-cognitive, analytical-critical and critical-purposeful.

Of the range of performance values offered by the type of building subjects involved in the experiment, the thermophysical behaviour requirement seemed the most able to offer a thorough picture of the response to the needs highlighted earlier, inasmuch as that, depending on material and therefore on the material nature of the resources, it influences quality and emissions capacity.

Considering the particular "numerical" nature of the data and values which may influence the achievement of the objectives, the formulation of the results has been guided by a model which makes reference to the instrument for Protocols and Codes. The goal was to produce a Support Instrument for Decision-Making, split into various scales and phases in order to assist the different users in the different choosing processes.

In particular, the general objectives were to:

- Identify new efficiency solutions for materials, defining the relationship between their energy intensity and the possibility of reaching the standardized minimum base value.;
- Understand whether high energy intensity of material corresponds to high efficiency with regard to the heat control requirements;
- Establish whether (and in what way) high energy intensity of material corresponds to high environmental impact;
- Try to define percentages of energy intensity that may be added to the material's unit of product separately from the aforementioned percentage of energy intensity.

The specific objectives were:

- To establish a criteria to evaluate how material can guarantee minimum efficiency (legal) with regard to its size and characteristic properties in order to demonstrate whether, in production phases, "less material corresponds to less energy";
- Establish a Decision Support System regarding the use of materials with low energy intensity in their entire lifecycle;
- Define a protocol for directing decisions;
- Create a coded instrument to assist the development of guidelines for the employment of building components made from materials with low energy intensity.

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The field of study has examined the following construction systems: 1. reinforced concrete 2. steel. All the sealing elements (horizontal and vertical) and their functional coatings have been considered with different material compositions. In particular the following materials have been considered traditional materials (cement, mortar, bricks e terracotta) and innovative building materials (cork and olive residues).

From these, the elements to have been taken as base parameters and parameters for comparison, elaboration and evaluation are those of Embodied Energy from the studies of A. Alcorn and G.J. Treloar (Treloar 1996).

The proposed Decision-Making Support Tool provides a system of weighting that involves all of the considered levels. A percentage of importance was assigned to each Problem, and in function of the fact that the actions are carried out in Mediterranean climatic context, greater weight has been given to aspects associated with and influencing the external thermal loads and thermal insulation.

Each Influence Category has its own weight and a weight relevant to the Problem, and each Influence Parameter has a weight relevant to the Influence Category and another weight relevant to the Problem of reference. The above in order to obtain an aggregated score and to include the relevant level of influence between the considered variables.

The present study has been verified through working simulations resulting in some initial problems regarding the functioning and gauging of the initial premises. On one hand it was possible to identify the areas in which to concentrate the greatest efforts, on the other, the simulations allowed the implementation of the procedure. It proved particularly difficult to obtain all the data relating to energy consumption during production and especially to make them homogenous as input data for the analysis due to their different units of measurement, material compositions and performances.

These materials were chosen as substitute products for an easier control on energy load and flows relating to the various phases of the cycles. As the experiment is still *in itinere* we reserve the right to supply the numerical data in the period following the final validation.

The study is currently experimenting with both traditional materials (cement, mortar and bricks) and innovative building materials such as cork and olive residues. These materials were chosen as substitute products for an easier control on energy load and flows relating to the various phases of the cycles.

In accordance with the numerous requests received from all sides regarding the increased environmental responsibility of the dynamics governing the construction industry, the importance and the role of support systems for the actions which influence the environmental quality of the planet and the checks on energy processes must also be highlighted.

We feel that directing studies towards the production and application of decision support systems which are reliable and easily transferable may facilitate checks on the general quality of the building sector and on the impact created by the latter, in this way supporting efforts to promote the sustainability of human actions.

The present research provides a contribution towards the identification of integrated strategies of requalification, developed according to local specifications, for a more efficient and more effective policy of intervention.

Therefore, the proposed tool enables the definition of a design criteria, based on the concept of the individuality of requalification actions. The tool should avoid rigid standardizations, but rather suggest approaches which unite the conformation of the building organism and the context in which the latter is localized.

The choice to simply consider the energy parameter as a prejudicial factor for strategies of intervention, could mislead users with little experience and limited technical and technological knowledge. It is also important to underline the experimental character of the proposed tool and to emphasize the possibility that it be implemented and improved through the addition of other parameters (for example durability and maintenance of technical solutions).

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## Materials Security, Productivity and New Business Models

Nicholas Morley  
Director  
Oakdene Hollins Ltd  
Aylesbury  
UK

### Abstract

Concerns over security of raw material supply by European businesses have increased markedly over the past five to ten years. In part this has been driven by a cyclical or super-cyclical commodities market and tighter supply. However there are underpinning changes in patterns of production and consumption driven by increases in global consumption, combined with the increased difficulty in locating and exploiting good quality resources in developed countries, and hence increasing reliance upon developing country resources, that are making longer lasting changes in the dynamics of natural resources supply.

Some of these difficulties in supply illustrate that ultimately raw material supply faces environmental rather than physical limits.

Studies by Oakdene Hollins and others have considered the low carbon energy generation supply chain, particular countries or regions, or particular groups of raw materials. Examples of areas of concern include the use of rare earths in magnets for wind power generation and in motors for electric vehicles; use of tellurium and indium in photovoltaic thin films. In all of these cases, the risks are generally to the resilience of individual company supply chains rather than presenting a barrier to the achievement of policy objectives such as the uptake of renewable energy generation.

Materials security can operate at a number of scales (for example organisation, country or region) and with a number of criteria. The methods used to analyse it are being continually made more sophisticated: issues that require development include better estimation of future economic impacts and the harmonisation of approaches to biotic and abiotic resources. Materials security gives additional impetus to initiatives aiming to conserve resources through their more efficient use, or through recovery in closed loop systems. We will examine the example of remanufacturing in business and its potential contribution to this issue.

Remanufacturing has a long history within the mechanical and electro-mechanical products sectors. It is often incorporated into business models that offer long term service arrangements, smooth lumpy revenue and costs from the sale of capital goods, or give access to more price sensitive market segments. Its environmental benefits are becoming increasingly recognised and quantified and the approach is being extended through adoption within sustainable procurement of selected product groups. Oakdene Hollins has developed four “golden rules” of remanufacturing:

Remanufacturing potential is determined through the optimal mix of: rate of product evolution, value and re-constructability

- Remanufacturing is at its most successful when most hidden
- Remanufacturing needs methods to reduce customer risk
- Recovery of “core” is the key to growth

It is also necessary to determine the environmental benefits of remanufacturing for each product group, since it is not necessarily the case that remanufacturing will always be beneficial, particularly with energy-using or energy-generating products where there is a high rate of energy efficiency improvement. In relation to materials security, it is becoming increasingly known in wind turbine components, and offers potential for the new generation of rare-earth based generators. Likewise in photovoltaic systems, remanufacturing of PV modules and inverters is able to increase resource efficiency and conserve insecure resources.

## Waste: Not! Turning Refuse into Quality Products - Emer O'Connell

Emer O'Connell

Communications Manager – European Pathway to Zero Waste (EPOW)

Environment Agency

London

UK

There is value in almost everything we throw away, but the stigma of waste and the regulations which surround it can deter both recyclers and users, and act as a barrier to resource efficiency. This paper describes a practical solution applied in the UK, whereby compliance with generic Quality Protocols allows waste materials to be reused safely without the burden of waste management controls. Quality Protocols are now in place for a range of waste materials, from recycled aggregates to non-packaging plastics, diverting hundreds of thousands of tonnes of useful waste away from landfill and onto the market as high quality recycled products and raw materials that customers can use with confidence. What was once unattractively labelled 'waste', is not! And with the barrier or unnecessary regulation removed, the door is opened to increased reuse of waste as a resource.

### Waste? Not? Turning refuse into quality products

Waste legislation exists for a reason. It protects the environment and human health and it can help create markets, providing a level playing field in which legitimate businesses can operate. When not carefully applied however, legislation and its enforcement can sometimes impose burdens on businesses, or act as a barrier to innovation and change.

Implementation of the EU Waste Framework Directive in the UK has driven major improvements in the management of waste and protection of the environment, and established the principle that waste should be viewed as a resource. A major review of waste policy in England set out the government's ambition to go further and faster in this direction: 'If we do,' the review stated, 'we will see the benefits not only in a healthier natural environment and reduced impacts on climate change, but also in the competitiveness of our businesses through better resource efficiency and innovation, helping to create a new green economy.'

### The origin of the Quality Protocol approach

Development of 'end of waste' Quality Protocols is one example of an approach that can contribute to achieving the benefits of a resource economy – in this case, through removal of unnecessary layers of regulation. It is an approach that is being promoted by the European Pathway to Zero Waste<sup>1</sup>, an EU funded partnership between the Environment Agency<sup>2</sup> and WRAP (Waste and Resources Action

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<sup>1</sup> [European Pathway to Zero Waste \(EPOW\)](#) is an EU Life funded demonstration project in the South East of England. EPOW is demonstrating the benefits of a range of approaches to resource efficiency, including the use of Quality Protocols. EPOW will share reports and findings with EU member states by the end of the project in March 2013.

<sup>2</sup> The [Environment Agency](#) is the public body with responsibility for implementing and enforcing environmental regulations in the areas of industry and waste management in England and Wales. The Environment Agency works closely with other similar bodies in Scotland and Northern Ireland.

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Programme)<sup>3</sup> in the UK which is demonstrating ways of improving resource efficiency and moving towards the long term goal of zero waste to landfill.

The Quality Protocol concept grew out of work originally undertaken by WRAP and the aggregates sector in the UK to develop a formalised quality control procedure for the production of quality aggregates from inert waste. Historically the UK has been able to source primary (virgin) aggregates from numerous sites. Growing pressure on natural resources, however, has led to the need for more sustainable sourcing of construction aggregates and driven the development of initiatives to increase demand for and production of secondary (recycled) aggregates from waste materials, and reduce reliance on primary resources.

The aggregates Quality Protocol set out a defined quality system that would both manage the environmental risks from waste construction feedstock, and control processing of secondary aggregates to the established standards applying to primary materials. With a uniform control process in place, producers of recycled aggregates and regulators could then be satisfied that waste materials had been fully recovered: effectively, a product and no longer waste. Potential purchasers could benefit from the knowledge that they would be buying a quality-managed product to common aggregate standards and could therefore have confidence in the secondary product performance.

The Quality Protocol approach hinges on giving businesses clarity on the point at which the recovered or recycled product will normally be considered no longer to be waste, and therefore not subject to potentially costly and burdensome waste management controls as otherwise required by the revised EU Waste Framework Directive (2008/98/EC). Uncertainty over the point at which 'end of waste' is demonstrated has been a key factor in inhibiting the development and marketing of products and raw materials derived from waste when these could in reality be safely and beneficially used to substitute for scarce virgin resources.

Successful implementation of the aggregates Protocol triggered the authorities in the UK to identify other reusable waste streams which could benefit from the same approach. Working with various industry sectors, and with funding from the relevant government departments in England, Wales, Scotland and Northern Ireland, the Environment Agency and WRAP have since gone on to develop and implement a further ten Quality Protocols covering a range of products from compost produced from biodegradable waste to recycled gypsum from used plasterboard. A full list of Quality Protocols in current use or in development in the UK is provided in Appendix 1. More information about existing Quality Protocols can be found on the [Environment Agency](#) website.

### Quality Protocols: process and requirements

Strict guidelines apply to the selection of waste streams suitable for Quality Protocols. It must be shown that the fully recovered product will

- have a certainty of use;
- be suitable for use, in the specific applications designated within the Quality Protocol, without the need for any further processing; and
- pose no greater risk to environment or health than the comparator non-waste product.

Quality Protocols are developed in conjunction with the relevant industry sectors, through a Technical Advisory Group whose members represent the various interests of producers, users, regulators or others. Market viability is normally established through market surveys and detailed financial impact assessments, while each waste material under consideration is subject to a detailed environmental risk assessment to ensure that the risks are no greater than those of the comparator non-waste product or material.

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<sup>3</sup> [WRAP](#) (Waste and Resources Action Programme) works in the UK to help business reap the benefits of reducing waste, develop sustainable products and use resources in an efficient way.



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Each Quality Protocol specifies:

- waste inputs and acceptance criteria;
- the standards that must be met;
- designated end uses permitted, and
- quality and records management requirements.

Quality Protocols also normally include guidance on good practice for use of the Quality Protocol product.

A process diagram showing the main stages and control mechanisms for the development of a Quality Protocol is provided in Appendix 2.

Quality Protocols are voluntary measures. Producers and users of secondary or recovered materials are not obliged to comply with a Quality Protocol. If they do not, however, the material they produce or use will normally be considered to be waste, and waste management controls will apply.

### Quality Protocols: the benefits

Quality Protocols have far-reaching benefits for business and the economy as well as for the environment. The Environment Agency has estimated that businesses could reap benefits in excess of £1 billion in cost savings and increased sales of Quality Protocol compliant products and materials by 2020. Table 1 below summarises the projected benefits of Quality Protocols up to 2020 for a number of measures.

Table 1 Projected benefits from Quality Protocols to 2020 (NPV)

Metric	Projected savings by 2020
Tonnage diverted from landfill	17 million tonnes
Raw materials saved	14 million tonnes
Cost savings to business and increased sales	£1 billion
CO <sup>2</sup> avoided	2.1 million tonnes

### Case study: recycling construction waste into quality secondary aggregate

An good example of a Quality Protocol in use is provided by work carried out by the Environment Agency (whose responsibilities encompass water and flood risk management as well as industry and waste regulation) to strengthen tidal defences at Lighterage Quay on the south coast of Cornwall in the South West of England. The project team set a goal of zero use of virgin aggregates. Working with colleagues in the waste regulation team, the project design team were able to identify and source the 2000 tonnes of backfill material required for the project from inert construction waste held at a local recycling centre operated by Cornwall County Council. The material had been destined for disposal in landfill.

Once it had been established that the waste material was suitable for the engineering use in question and that it could be processed into Quality Protocol standard recycled aggregate, processing was undertaken in-situ using a mobile crushing and screening unit to produce a suitably graded material.

The proximity of the recycling centre to Lighterage Quay (approx 12 miles) meant that regular 'just in time' deliveries of recycled aggregate could be made to site, saving valuable space at the quay and avoiding double handling of the material which saved time and effort on the project.

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Direct benefits to the project included 2000 tonnes of building waste reused instead of landfilled; 2000 tonnes of virgin aggregates saved; a 70% reduction in carbon footprint (compared to use of washed virgin aggregate) and financial savings of c£55k (compared to washed virgin aggregate).

The project also secured wider benefits for the local community as the scale of the contract allowed Cornwall County Council to procure new screening plant for the recycling centre and establish reprocessing of construction waste as a continuing activity on the site. This has in turn secured local jobs and will continue to save virgin raw materials and contribute to the local economy in the future.

### Developing new Quality Protocols

As previously mentioned, a number of new Quality Protocols are under consideration or in development for a range of further waste streams. Three of these are being developed by the European Pathway to Zero Waste project. They are:

- biomethane from the upgrading of landfill gas and biogas from anaerobic digestion (AD) for injection to the gas grid and use as a vehicle fuel;
- ash from the incineration of meat and bone meal (MBMA) for use as a phosphate fertiliser substitute, and
- asphalt waste containing coal tar (AWCCT), which largely arises from highway and utilities construction and maintenance works, for reuse as a secondary aggregate.

Potential markets have been shown to exist for all three of these waste-derived materials. Market survey and financial impact assessment information indicates that biomethane from waste has the potential to supply 1% of UK domestic gas demand by 2020, provided a Quality Protocol can be implemented and some other minor regulatory barriers can also be overcome. Reuse of MBMA as a substitute for virgin phosphate fertiliser could divert 117,000 tonnes of waste from landfill over the first ten years of a Quality Protocol. The reuse of asphalt waste under a Quality Protocol could save business £11 million over the same period. Environmental risk assessments and work to identify appropriate standards and specifications for the safe use of these materials are currently underway, and will determine the practicality and timescale for introducing Quality Protocols.

Progress with all three protocols under development can be followed on the [EPOW pages](#) of the Environment Agency website.

### Quality Protocols: the future

To date, most of the cost and administrative workload of developing Quality Protocols has been met from the public purse. Increasingly, the authorities are looking at how industry sectors – as the main beneficiaries of Quality Protocols – can take more responsibility for establishing end of waste decisions and taking forward the Quality Protocol approach to resource efficiency. To this end, the Environment Agency is leading a separate EU Life funded project entitled Equal – **Ensuring Quality** of waste-derived products to achieve resource efficiency - to:

- demonstrate the environmental impacts of waste-derived products on the environment through a series of field trials on four Quality Protocol compliant materials
- empower industry to self-assess their compliance with Waste Quality Protocols with the aid of a Quality Protocol compliance e-tool and guide, and
- demonstrate a successful methodology for making end-of-waste decisions by developing an end-of-waste e-tool that enables businesses to make their own end-of-waste decisions.

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Results of the Equal project, and the compliance tools and resources produced, will be shared with businesses and regulatory bodies across the UK and EU member states.

### Conclusions

End of waste Quality Protocols make it possible for materials that are derived from waste to be safely used and marketed as quality products. They help encourage productive reuse of materials that would otherwise go to landfill, helping businesses navigate often complex waste management regulations by explaining clearly what must be done to produce fully recovered, non-waste products. Quality Protocols bring far-reaching benefits for both the environment and the economy. As well as diverting significant volumes of waste from landfill, they generate cost savings for industry, create new market opportunities for businesses, reduce pressure on scarce virgin raw materials with associated benefits of carbon emissions avoided.

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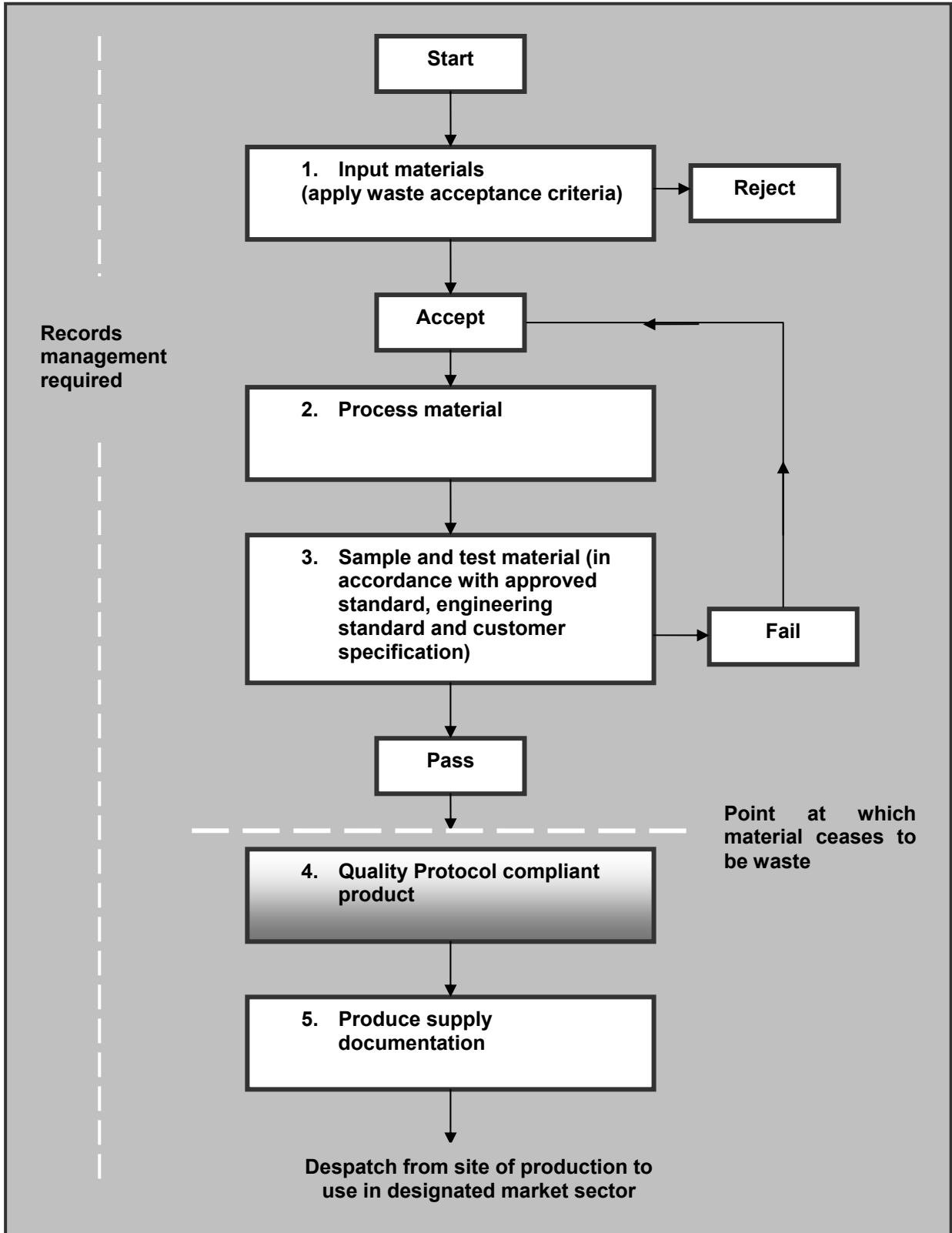
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### Appendix 1 End of waste Quality Protocols implemented or in development in the UK

Waste type	Title	Published
Aggregates	<u>Quality Protocol for the production of aggregates from inert waste</u>	2005
Biodegradable waste - anaerobic digestate (AD)	<u>Quality Protocol for the production and use of quality outputs from anaerobic digestion of source-segregated biodegradable waste</u>	2010
Biodegradable waste - compost	<u>Quality Protocol for the production and use of quality compost from source-segregated biodegradable waste</u>	2012
Cooking oil and rendered animal fat	<u>Quality Protocol for the production and use of diesel derived from waste cooking oil and rendered animal fat (quality biodiesel)</u>	2009
Flat glass	<u>Quality Protocol for the production of processed cullet from waste flat glass</u>	2008
Lubricating oil	<u>Quality Protocol for the production and use of processed fuel oil from waste lubricating oils</u> In addition, the accompanying <u>regulatory position statement</u> provides additional information	2011
Plasterboard	<u>Quality Protocol for the production and use of recycled gypsum from waste plasterboard</u>	2010
Plastics (non-packaging)	<u>Quality Protocol for the manufacture of secondary raw materials from waste non-packaging plastics</u>	2009
Poultry litter ash	<u>Quality Protocol for the production and use of treated ash from the incineration of poultry litter, feathers and straw</u>	2012
Pulverised fuel ash and furnace bottom ash	<u>Quality Protocol for the production of pulverised fuel ash (PFA) and furnace bottom ash (FBA) for use in bound and grout applications in specified construction and manufacturing uses</u>	2010
Tyres - tyre-derived rubber material	<u>Quality Protocol for the production and use of tyre-derived rubber materials</u>	2009
<b>Quality Protocols in development or under consideration</b>		
Asphalt waste containing coal tar		
Biomethane from landfill gas or anaerobic digestion (AD) of waste		
Incinerator bottom ash		
Meat and bone meal ash		
Paper sludge ash		
Pulverised fuel ash		
Steel slag		
Wood		

Appendix 2 Main stages and control mechanisms of a Quality Protocol



## How Design Relates to Waste: A Categorization of Concrete Examples

Isabel Ordoñez

Phd Student, Design for Sustainability

Division Design & Human Factors, Department for Product and Production Development

Chalmers University of Technology

Sven Hultins gata 6, SE-41296. Göteborg

Sweden

Professor Ulrike Rahe

Division Design & Human Factors, Department for Product and Production Development

Chalmers University of Technology

Sven Hultins gata 6, SE-41296. Göteborg

Sweden

### Background

Waste generation grows faster than the population due to increased consumption (Baker et al. 2004). Simultaneously, the availability of resources and the ability of ecosystems to provide them are decreasing (Holmberg 1998). Keeping materials in continuous loops gains importance (McDonough & Braungart 2002; El-Haggar 2007; Foundation 2012), not only as sustainable waste management (WM), but as a way to provide the materials future generations will require.

### Aim and Method

In order to explore the existing relation between WM and Design, an interview study was carried out in 2011, targeting designers who have worked with waste (11) and WM professionals (14). The interviewees originated from Sweden (13), Germany (five), Egypt (one), India (one) and Chile (five) to provide cultural diversity to the study.

The interviews were semi-structured in character following an interview guide. The interviewees were introduced to the objectives of the study and the definitions used in the guide. They were asked if they considered design to have any relation to WM. As a trigger, the interviewees were later shown two visual cards with examples of products that relate design and waste. They were asked to comment on these and name projects which according to their knowledge were good examples of how WM and design relate.

### Outcome

During the interviews 74 examples came up in an unstructured way. This article categorizes the examples obtained in the study into five relevant groups, which are explained and exemplified with a selection of their best cases: I. Material Recycling; II. New Materials from Waste; III. Redistribution; IV. New Products from Waste; V. Design for End-of-Life.

#### I Material Recycling

The examples in this category refer to industrial re-manufacturing of material into similar products, maintaining their qualities. The recycling industries mentioned were: **Paper, Glass, Aluminum, Metal, PET and Plastic**. This makes the sorting of these materials a profitable endeavor.

It is interesting to notice that aluminum was mentioned separately from metals in general, as was PET from recycled plastics. Even though plastic recycling (without specifying what polymer) was not

considered an important industry, the use of recycled plastic was mentioned as input material for small products, garden furniture, etc.

Recycling varies between developed and developing countries. The first rely on formal recycling centers where everybody is expected to separate their waste into different fractions. In developing countries however informal recycling is done by people of low income, as means of improving their economical situation.

### II New Materials from Waste

Other examples pointed out the development of new raw materials from waste. These materials, usually composites, aim to be sold in the material market, so they can be used for products that serve a different function, benefiting from it's new properties. The cases that best clarify this are:

#### 1. Polyplank

Polyplank is recovered thermoplastics mixed with wood fiber (wood mill by-product) that generate a composite that can be string or injection molded. It does not require surface treatment and can be processed like a normal wood plank (Polyplank 2012). It can be recycled by the same producers between 4 to 7 times before they need to add more Polyplank composite. For final disposition the material's energy can be extracted through combustion.

#### 2. Tectan

In an effort to make their material more recyclable, Tetra-pack launched the Tectan board in 1991. Made only of reused tetra-pack that were grounded, laid into sheets and binded with heat and pressure. The polyethylene fraction of the original packagings acts as adhesive, requiring no extra material. The boards composition is the same as the original tetra-pack material: 75% paper, 20% polyethylene and 5% aluminum, resulting in a material with good insulation properties, water resistant, noise absorbing, thermoformable and recyclable (El-Haggar 2007).

Despite this apparent success, tectan boards have not proliferated and Tetra-pack now promotes paper mill recycling of their products (TetraPak 2012). The company that developed the original board continues to make tectan products for industrial applications out of packaging production waste.

#### 3. Waste Incineration Ash

Some MSW systems incinerate the waste that is not separated for recycling. This allows them to extract energy (in form of heat and sometimes electricity) from the waste. After the process the waste is reduced to ashes, that occupy only 10% of it's original volume (El-Haggar 2007). Depending on the composition of the waste incinerated, left over ash could be considered harmless inert material from which land reclamation, bricks, tiles and pavement can be produced. Another common use for this ash is as landfill covering material.

### III Redistribution

Other examples from the interviews were non-disposal systems that provide alternative routes for specific waste streams, mainly through repair and/or relocation.

#### 1. Second-Hand markets

Mainly focused on clothes, furniture and household appliances, second hand markets provide a valid alternative for products that are still in conditions to be used. They can be formal and established (e.g. Myrorna in Gothenburg) or informal (e.g. flee markets, Blocket 2012), where anybody can sell items. The quality of the items found in second-hand stores was regarded as acceptable or good by the interviewees from EU countries, where as it was frequently seen as not acceptable in non-EU interviews.

#### 2. Charity Organizations

Many organizations operate doing material relief for people in need around the world, relocating donated goods. E.g. Human Bridge Charity, a Swedish NGO collects, sorts, packs and ships clothes and reconditioned hospital equipment to development organizations (Human Bridge 2012).

### 3. Hacking and DIY movements

One interviewee suggested that hacking<sup>1</sup> helps people find alternative uses for things they have instead of discarding them. Sites like (Hack-a-Day 2012) provide useful information. The same is true for DIY initiatives, that openly show how to re-purpose things. Crabbe 2012 says that the DIY movement aims to help people reduce their consumption rather than generate new products for the market, so these efforts can be seen as waste prevention.

### 4. WEEE

WEEE is a special case: Given it's toxic components it cannot be disposed with normal waste, so collection systems have been developed in many cities. It also contains a high yield of valuable material that make it interesting for recycling. What happens with WEEE varies greatly from one location to another:

- To recuperate components and fix non functioning WEEE was considered a big activity in Pune and Cairo, mainly carried out by the informal sector. The prices for repairing electronic equipment are well under the costs for new equipment, due to the availability of cheap labor. When equipment can not be fixed it is dismantled and it's useful components separated for latter use. The rest is stripped of it's valuable metals for recycling. However, this brings health and environmental problems (Park 2010) and both governments struggle in attempts of formalizing this activity to include the informal workforce already skilled in this field (Fahmi & Sutton 2010; Pune Municipal Council 2006).
- Informal recycling of WEEE is done in Chile, but not as massively as in Cairo or Pune. Recycla Chile, was the first formal company in Latin America to recycle used computers. They offer WEEE recycling services to companies, charging for dismantling discarded equipment and assuring safe disposal of hazardous components. During this process they recuperate valuable materials and components for reuse or recycling. They use some functioning components to refurbish computers, used later in social programs (BusinessWeek 2009).
- In Europe repairing WEEE to be used locally was considered unprofitable. A Swedish interviewee recalled a project that refurbished computers to send them to countries in Africa as charity. This common practice in developed countries turns out to be problematic: Even though trading used electronic goods to developing countries is intended to help them use ICT, it poses a challenge of how to handle the E-waste that remains (Basel Convention 2011). This report states: "30% of the used EEE imported was non-functioning (e-waste): half of this amount was repaired locally and sold to consumers and the other half was not repairable." It is also unclear how long the repaired EEE works after it is sold, generating something called "near-end-of-life" equipment, which can be considered a big source of E-waste in West African countries.

## IV New products from Waste

Commonly referred to as Up-cycling, this category is the one that generated most examples. It consists of re-manufacturing waste by means of product design, converting wasted resources into ready to use products.

### 1. WEEE Jewelry.

This type of handcraft will probably not tackle the escalating WEEE problem, but it gives an alternative. It is a recurrent phenomenon with several jeweler entrepreneurs offering their recycled creations at stores, fairs and web-pages. Results vary widely in style and quality. E.g.: (Arteco 2012; Etsy 2012)

Figure 1 shows WEEE cuff-links, by David Wright.



Figure 1

<sup>1</sup> Heavily modifying software or hardware of their own computer or anything else, either to make it better or faster to give it added features or to make it do something it was never intended to do.



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### 2. Bags made from recycled material.

Also a recurrent item, done by entrepreneurs as well as bigger companies. It varies widely in quality and style.

Interviewees considered it both good and bad examples, depending mainly on the final product's quality. Examples made out of single materials are often better finished. Some examples that use woven food wrappings achieve a nice final product, but other simply do not. TerraCycle 2012 offers both kind.



Figure 2

A good example is Retape 2012. The designer Lucrecia Lovera makes products out of woven used magnetic tape. This won her the ModaFAD prize for best male collection in 2008. She says the idea came up testing different materials to work with. Between other properties it was stable, strong, durable, lightweight and, of course, eye-catching Figure 2: Partyparty, by Retape.

Demano, from Barcelona is another good example. They use discarded cultural events banners Figure 3 Marbella bag, by DeMano 2012.



Figure 3

### 3. Showraum

This group produces handmade furniture and product design from used and found material. The self denominated "Kreuzberg (Berlin) based resource for hand made design", display ready made products and receive orders for custom made furniture for their "growing network of international designers". They aim for special things that are unique and well made. Figure 4: CMYX, by Kerti. Image from ShowRaum 2012.

### 4. Reline tableware

This set of tableware was made by collecting pieces of white pottery, that no longer had all the pieces to make a set. To give them a visual unity, the designer ties the group with a flashy pink line. Figure 5: Reline, by Anna Bormann. Image from Bormann 2012.



Figure 4



Figure 5

### 5. Schubladen

This workshop-store refurbishes old drawers incorporating them into new bureaus. The drawers are collected, treated and combined to give each piece of furniture a part from another time. The designers aim to give high quality long lasting furniture, with a piece of history that makes it unique. Figure 6: Möbel 37|08. Image by Nina Straßgütli, SchubLaden 2012.

### 6. Remade in Chile

With a yearly design contest, this non profit organization aims to promote recycling, reuse and environmental care with design in Chile. It has collected many good examples over the years, worth looking into. Figure 7: Implum, by Genoveva Cifuentes. Image from Remade in Chile 2012. This 2011 winner made biodegradable products for plants made out of agglomerated plum seeds.



Figure 6



Figure 7

### 7. Creatables

This young Swedish design company develops products using scrap material from different industries. Sometimes they fit their die-cut design into the same production process from the "hosting industry". They call this "production hacking", which has the advantage of requiring no extra energy to make their product (Creatables 2012).

8. Espora did workshops under a project of the foundation "Casa de la Paz" in Chile, aiming to teach informal recyclers from the municipality of Peñalolén how to work discarded materials in order to generate more value by their occupation. PET recycling in Chile gives little or no profit to informal recyclers. However, products from PET can be directly sold to interested public generating a better revenue. That is why this broadly discarded material was chosen as base for the "Re-clear" workshop. Figure 8: Pencil-holder "Cala", by Espora, Diseño Conciencia 2012.

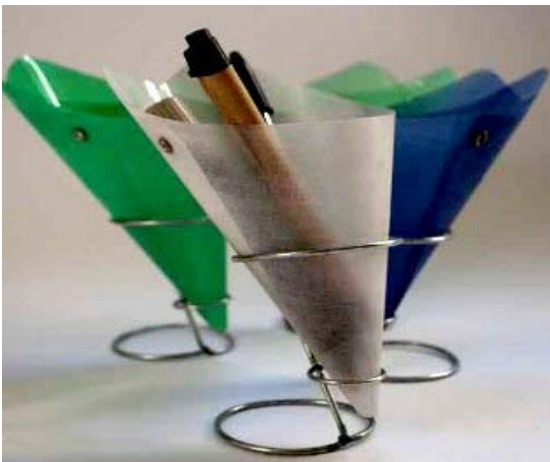


Figure 8

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Figures 9 -11 are some of many examples omitted due to space limitations.



Figure 9: Wretman-stället by Torstensson 2012 uses leftovers from silverware production.



Figure 10: Profil belts by Yeayea 2012, out of bike



Figure 11: N+ew, by Alonso 2012. Seat-installation of encapsulated WEEE.

## V Design for End-of-life

This category groups products that have been developed considering their end-of-life stage, in parallel to other product requirements. Planning for the end-of-life can avoid disposal all together, or even turn used materials into something beneficial.

1. Glass containers for ketchup or mustard used as glasses.

Different food is sold in glass containers, but some companies (e.g. Maille, Bautzner Senf, Amora, etc) make efforts to have their packing be used as drinking glasses afterwards. These drinking-glass-shaped jars are sold with a removable plastic lid to distribute the product. This was regarded by the interviewees as a good practice in packaging. Although one interviewee did consider it sometimes falls to the excess, giving as example seasonal products that are sold in very elaborated ceramic vessels.

2. PeePoo

Peepoo is a biodegradable plastic bag that one can use as a toilet. It has an extensible inner lining that facilitates this action (Figure 12, image from Peepoople / Niklas Palmklint / Peepoo studio photo). It is intended as a sustainable sanitary solution for slum areas and refugee camps. It converts the common use of the “flying toilet” (feces in a regular plastic bag, latter thrown out the window) to a more sustainable practice. The difference is that, besides being biodegradable, Peepoo has an inner coating of urea (non hazardous common fertilizer). When the urea comes in contact with feces or urine it generates a chemical reaction that kills the bacteria and parasites that normally occur within a couple of weeks. This means that when Peepoo degrades into the soil it becomes a harmless fertilizer rich in nutrients (Peepoople 2012).

3. Janipad

This product is a biodegradable sanitary pad made out of paper produced with water hyacinth. The project was developed during a course in Kenya by students from Chalmers University (Sweden). Water hyacinth is a problem in Lake Victoria, so the students develop a biodegradable solution with it (JaniPad 2012).

4. ReturDesign, furniture made out of cardboard.

This is a design studio, located in Stockholm, that does furniture with cardboard. They use new heavy duty cardboard to create diverse type of stable furniture. To provide with easy recycling of their furniture the pieces have no treated surfaces and can be mounted and dismantled by the user. A clear example of design for recycling. Figure 13: Big Chaos shelf, by ReturDesign 2012.



Figure 12



Figure 13

### Conclusions

Besides serving as a reference list for good examples of resource usage, the categorization clarifies barriers and strategies adopted in different cases of relating design with waste.

**Material Recycling** allows for processing large volumes of discards, making it very suitable for waste management as an alternative for disposal. However, many materials tend to down-cycle rather than recycle, losing properties with every re-processing. Despite this, every new cycle the materials get, there is a saving of raw materials to perform that task. This is called cascading, and should be prioritized over disposal. Some materials recycle well (e.g. metals, glass) so the difficulty for having them in effective closed-loop systems lies in separating them correctly after their usage. This is why collaboration between design and waste management is crucial and strategies like Design for Disassembly or Design for Recycling are vitally important if we expect to recover most materials used.

Making **New Materials from Waste** broadens the possibilities that material recycling offers. It also allows for processing large volumes and by combining two or more materials a new material with enhanced properties can be obtained, which may prove to be more valuable. Much testing is required to obtain the desired properties, but the use of waste allows for cheap input material, which is a promising start for a profitable venture. How environmentally friendly this type of recycling is, however, can be widely debated. It still provides a promising alternative for material disposal.

These first two categories are of great importance given large volumes of discards they can handle. However, they only take advantage of waste as raw materials, eliminating their component or product properties. Instead, **redistributing** goods benefits from all these properties. Discarded products have to go through selection, sorting and maybe repair before being resold or redistributed. This is more work intensive than recycling and normally collects less revenue. It helps as an alternative to discarding useful products, but it is unclear if this reduces the need of new production. It also lacks improvement of products.

Up-cycling, or making **New Products from Waste** allows for product improvement while maintaining the properties of its materials and some components. It allows for mixing the discarded elements with new materials, improving its quality and performance. Even though this is an activity that is becoming common between designers, not that many are able to industrialize their production, falling into labor intensive handcraft. The main barrier to massify up-cycled designs is the irregularity of the components in the waste streams. To bridge this problem designers should select a material that has a constant flow and arrange to get access to that material on a regular basis.

However, up-cycling is still a palliative solution: we still generate waste. Ideally production should **Design for the End-of-life** of their products, by devising how to obtain the best possible value from their products once its use stage is over and communicating it to the users. This avoids having to figure out how to handle the discards and provides an optimal, well thought of solution for that product to reintegrate to society, eliminating the concept of waste.

These final two categories take full advantage of discarded products and by use of design-thinking achieve the best results in closing the loop. Integrating end-of-life considerations to early design phases should be given priority if we ever expect to transform waste handling into resource management. These categories show how complementing design and waste management truly delivers better results.

### Further work

Further research efforts are needed to see how we can reformulate the design process to serve as a tool for waste management. Using the gained categorization, we can strengthen the strategies used and include new ones to conquer the barriers found for linking waste with production.

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## **Investigating The Life-Span of Cork Products and Appropriate Use Of The Material – Advanced Results Of A Longitudinal Study With Users**

Ana Carina Pereira

PhD Researcher

TU Delft, Industrial Design Engineering

Design for Sustainability and Forest Research Center, School of Agronomy

Technical University of Lisbon

Delft

The Netherlands

Han Brezet

Professor

TU Delft, Industrial Design Engineering, Design for Sustainability

Delft

The Netherlands

Helena Pereira

Professor

Forest Research Center, School of Agronomy,

Technical University of Lisbon

CEF – Centro de Estudos Florestais

Lisbon

Portugal

Joost Vogtländer

Associate Professor

TU Delft, Industrial Design Engineering, Design for Sustainability

Delft

The Netherlands

### **Abstract**

Products with long life-spans are generally preferred from an environmental sustainability perspective. This research addresses the longevity of cork products through a longitudinal approach, and advanced results of the 16 months moment are presented here. The aims are to identify the appropriate use of the material, and evolution of influencing aspects overtime.

For the moment, with few exceptions, the longevity of cork products is very good; most products are still being used, and durability is highly assessed by users. From the analysis of some cases, it can be concluded that the application of cork in the products being studied is appropriate or semi-appropriate; in the later there are opportunities for improvement related with a few problematic situations of deterioration and surface finishing. And in general, the aspects influencing product life-span have a



positive evolution in time. The research provides original and enriching information in the field, from a design perspective.

### Introduction

#### Cork – origin, applications and materials

Cork is a renewable resource, the outer bark of the cork oak tree, and can be removed periodically from the stem without endangering tree vitality. The cork oak forests occur in the western Mediterranean region, and in addition to their productive economic role they provide multiple important functions, such as preventing soil erosion and the protection of biodiversity (Costa and Pereira, 2007; Pereira et al, 2009). Since tree growth is slow, and regeneration often difficult, this can be considered a limited resource; as such, in this context, addressing the life-span of cork products is an important resource conservation strategy (Pereira et al, 2011b).

Wine stoppers are the main cork application, and others include construction materials, floating devices, and use in aeronautics (Gil, 1998; Silva et al, 2005; Pereira, 2007); more recently cork has also been increasingly explored in the field of design (e.g. Mestre, 2008). As a material, cork is light, rather impermeable, and chemical and biologically stable (Pereira, 2007). In addition to natural cork, there are already several other cork materials, such as: white agglomerates, black agglomerates, rubber-cork, cork gel, CPC - cork polymer composite, cork wool, cork paper, cork textile/ skin (e.g. Mestre, 2008; Gil, 2009).

#### Product life-span and appropriate use of the material

Products with long life-spans are generally desirable from an environmental sustainability perspective (Meadows et al., 2004; van Nes, 2003; Vezzoli and Manzini, 2008; Cooper, 2010), because they enable to reduce resource use and the subsequent outflows to the environment. Since circa 1900 the number of materials available proliferated; existing materials are now unlimited, as are also the possible combination of them in composite materials (Manzini, 1989, p.42).

While this enables the discovery of interesting new applications and functions, the use of new materials in unconventional contexts can result in highly uncertain product life-spans. On the other hand, from a material perspective, even though there can be numerous applications for a single material, perhaps only some of these are appropriate if there is the design challenge to accomplish more sustainable solutions through long life-spans.

From the above, the concept of 'appropriate use' of the material could be characterized as an utilization in which the properties of the material suit naturally (without much transformation), in which the material in product withstands use through time (enabling long life-spans), and in which the products are appreciated and valued by users (e.g. technically and aesthetically). Additionally, applications in which these aspects are more clearly distinguished from solutions obtained with other materials, could be regarded as offering a higher positive differentiation (Pereira et al, 2011b).

#### Research aim and questions

This research aims to enhance the understanding of product life-span (influencing aspects and extension potential) through the exploration of the concept of 'appropriate use' of the material. This is accomplished with the analysis of several product cases in the context of a longitudinal study.

##### Research questions:

RQ1 – How is the life-span of cork products? How long do they last?

RQ2 – How appropriate is the use of cork when applied in certain products?

RQ3 – How is the evolution of product life-span? How do aspects influencing life-span evolve over time?

## Methodological aspects

### Study set-up

Several cork products are being used in a longitudinal study. At specific moments interviews are performed with the users, and photographs are taken to register changes in time.

Planning: the planning of the moments to collect information is (in months): [0m], 3m, 8m, 16m, 24m, 36m. This paper is based on the results from the 16 months moment. Results from the previous moments can be found in Pereira et al (2011a, 2011c, 2012).

Products: 18 cork products for household (bath, kitchen) and personal use (leather market, stationary) were selected and acquired, contemplating different cork materials and producers. With few exceptions, a minimum of three units of each product is being used.

Participants: there are 31 participants, and approximately half of them are related with research on cork or wood; the study is being performed in Portugal.

Interview: the interview is semi-structured, including open and closed questions coherently organized. This was considered appropriate for the explorative scope of the research.

### The products (a selection)

Figure 1 shows a selection of cork products for household and personal use from the study.



Figure 1 – Four examples of cork products included in the study

### Contents of the interview

#### Use of the product (general characterization)

The 1<sup>st</sup> group of questions aimed to characterize the use conditions: to confirm if the product is being used, how the product is used (context of use) and how often it is used (intensity of use).

#### Product appreciation (general)

In the second part the aim was to accomplish a general appreciation of the products, and users were inquired namely about likeness (if they like using the product), and satisfaction (if they are satisfied and would recommend the product).

#### Product evaluation (specific keywords) – five aspects

To accomplish a more specific appreciation and evaluation of the products, five aspects were selected for exploration and assessment in the study. These are: performance (e.g. functionality), quality (technical or broader concept), durability, aesthetic appreciation, and attachment. At this moment participants were asked to evaluate the aspects with a one to five [1-5] scale, except for attachment which was interpreted as no, yes but or yes (2 to 4 respectively). In the first moment (3m) participants provided only qualitative appreciations; these were then transported to scale by the researcher.

Comparison/ others (several)

A last group of questions addressed some other aspects: comparison with other materials; observed differences in time (comparison with new); and, required maintenance/ cleaning.

**Results**

In this section the general results will first be introduced; following there is an analysis of cases concerning the appropriate use of the material; and finally, the evolution of life-span over time are presented.

**General results**

In most situations the products continue to be used, in equal context and intensity of use. Good condition, look/ durability of the products was the main key issue mentioned by participants at the beginning of the interview (Fig.2 a). And, in most cases, users state that they like using the products, are satisfied and would recommend them (Fig. 2 b).



Figure 2 – Key issues and expression of satisfaction and recommendation provided by users

With regard to the evaluations of the products according to the five aspects or parameters, in general, these are also good/very good [4] or excellent [5], as can be observed in charts of Fig. 3 below. More exceptions occurred in household products, which have a higher incidence of moderate and negative situations; although, this happened only in some product cases, and is therefore not representative of the general opinions of the products. Some of these will be detailed in the following section.

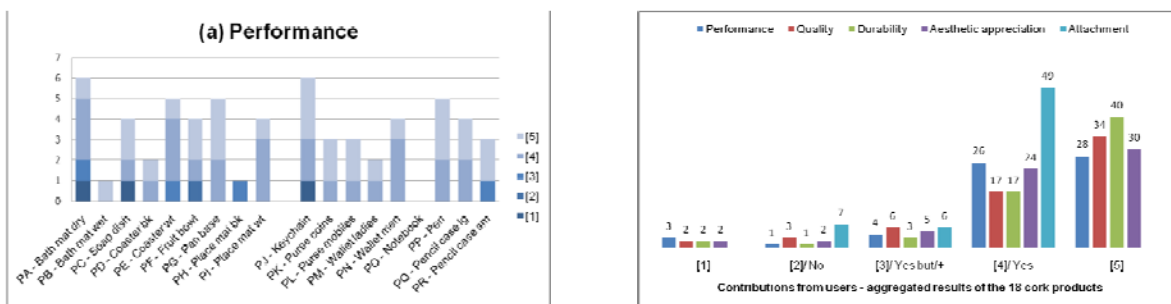


Figure 3 – Evaluations of performance and aggregated results of the five aspects

In the performance chart above, all the contributions from users are presented, and the darker squares represent the problematic situations. From the aggregated chart, it can be inferred that the five aspects have very similar evaluations: often, the occurrence of a specific issue (e.g. deterioration) has repercussions in several parameters, though not simultaneously; this is observable later in the evolution section. Another aspect to point out is the incidence of higher durability assessments (40 as [5]).

As such, from the general results, it can be concluded that the life-span of most cork products is very good for the moment; most are still being used, users like using them, are satisfied, and often evaluate the five aspects as good/ very good [4] or excellent [5].

Cases of appropriate use of the material

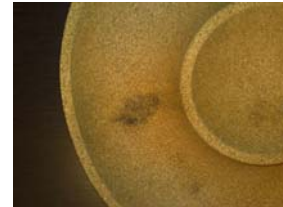
In this section some product cases for household and personal use are presented. The products are firstly introduced together with images and the evaluation charts of this 16 months moment. Following, there is a synthesis table and a short description of each. Analysis of appropriate use in made by the researcher, from the answers provided in several questions, but users have not been explicitly asked about it. As a starting point it was assumed that the use of the material is appropriate, unless proven otherwise.



PA – Bath mat dry (PA3 – U6)



PC – Soap dish (PC3 & PC1)



PF – Fruit bowl (PF2 – U18)



PK – Purse coins (PK3 – U18)



PN – Wallet men (PN2 – U21)



PP – Pen (PP4 – U21)

Figure 4 – Images of products selected for analysis of appropriate use of the material (16m)

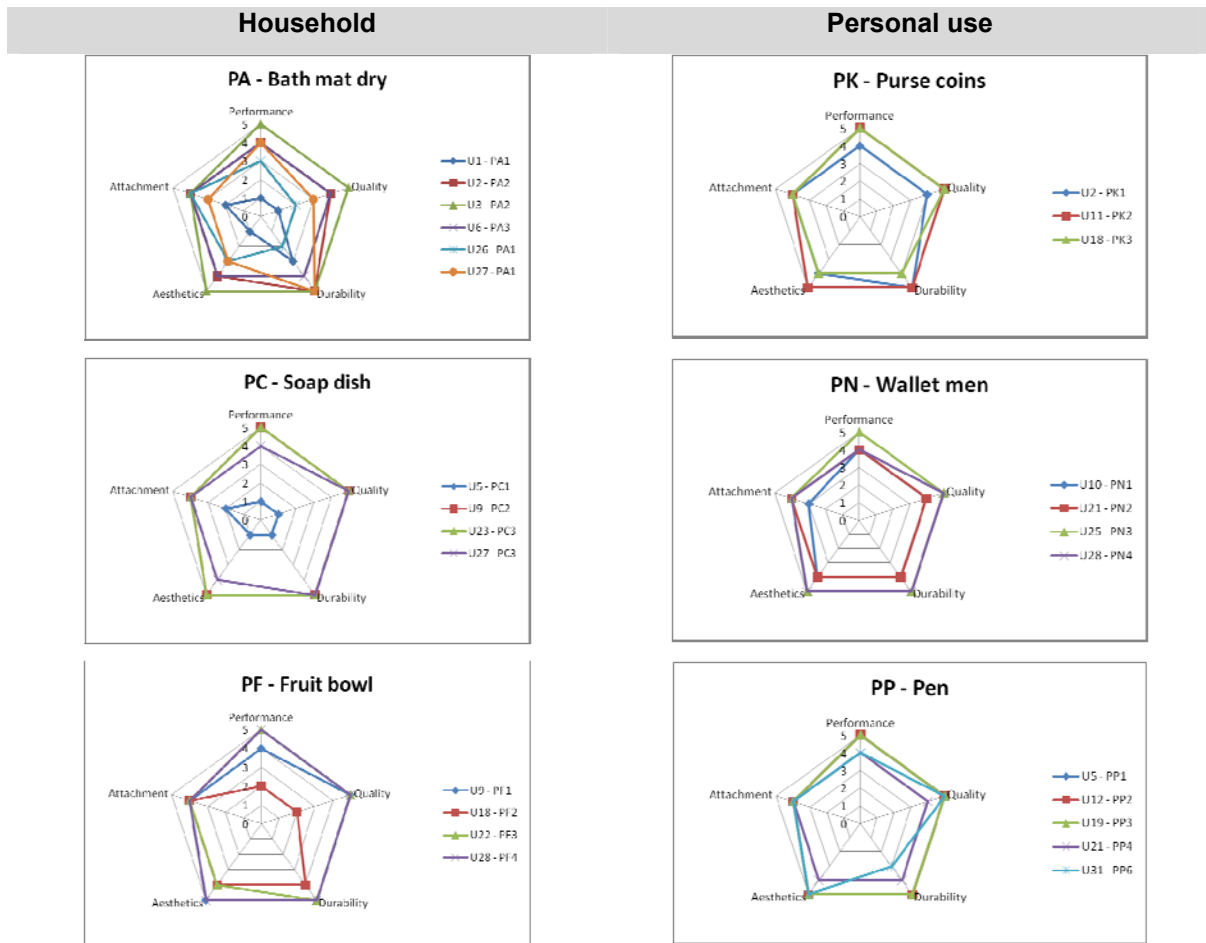


Figure 5 – Evaluation charts of a selection of household and personal use products (16m)

Product	Case	Satisfied	APPROPRIATE USE OF THE MATERIAL [+]	NON-APPROPRIATE USE [-]	Final
PA – Bath mat dry	PA1 – U1	NO			
	PA1 – U26	YES BUT	Being cork, colour, texture, visual look; it's pleasant and Portuguese.	Deterioration, stained, ugly. No appreciation. Change material, + resistant cork; different finishing water resistant, darker colour to avoid/ disguise dirt.	NO
	PA1 – U27	YES		Deterioration, darkening. Change: apply varnish for protection, avoid deter.	YES BUT
	PA2 – U2	YES	Very functional, comfortable, anti-sliding, durability, pleasant tactility, temperature.	Deterioration and ageing. Change finishing of border to avoid deterioration.	YES BUT
	PA2 – U3	YES	Excellent material, functional, pleasant tactility, comfortable.	Dirt, finishing. Change finishing to avoid dirt.	YES BUT
	PA3 – U6	YES	Pleasant tactility, use noticed but acceptable look, in good condition, would change nothing to allow material to breath (water).		
PC – Soap dish	PC1 – U5	YES BUT	Appreciation of product in general, the design.	Deterioration (darkening, cracks, crumbles/ dissolve); use stopped. Low efficiency of coating, impermeability. Change use for decoration (keys hall).	NO
	PC2 – U9	YES	Resistant, impermeable, in good condition (durable implicit). General appreciation, and of large dimension (several soaps for bath).		YES
PF – Fruit bowl	PC3 – U23	YES	General appreciation, would change nothing.		YES
	PC3 – U27	YES	In good condition (durable implicit; thought would be more damaged).		YES
	PF1 – U9	YES	Resistant, good condition (thought would get more stains).	Some (few) stains.	YES
PK – Purse Coins	PF2 – U18	YES BUT	Very practical, appreciation of the shape, aesthetics and design.	Stains not totally removable. Would change coating to enable easy cleaning and maintain aesthetic appearance of the product.	NO
	PF3 – U22	YES	Good condition, unchanged look, condition, durability.	Slight (few) stains disguised. Would change coating to avoid stains (no dislike but prefer without).	YES BUT
	PF4 – U28	YES	Good condition, durability, resistance to daily use including rot fruit	Gets dirty. Would change finishing to avoid dirt.	YES
	PK1 – U2	YES	Very functional, surprising application of material, pleasant, beautiful, appreciation of product in general.		YES BUT
PN – Wallet men	PK2 – U11	YES	Resistant, durable, in good condition, looks new except for dirt.	Gets dirty. Would change finishing to avoid dirt.	YES BUT
	PK3 – U18	YES	Very practical. Surprised with the existence of daily products so practical made of cork. Appreciates usability.	(Dirt mentioned but with no depreciative meaning, normal)	YES
	PN1 – U10	YES	In good condition, durability, cleaned once. Well made – cork doesn't dissolve; instead of surface wear or scratch it wrinkles. Appreciation product in general.	(Wrinkle mentioned but with no depreciative meaning, normal)	YES
	PN2 – U21	YES	Durability, resistance (to traction everything), some dirt but can be cleaned. Very good touch; natural or synthetic leather is colder.	(Dirt mentioned but with no depreciative meaning, normal)	YES
	PN3 – U25	YES	In good condition, durability and still looking good; gets darker with ageing, like leather. Appreciates beauty, malleability and tactility.		YES
	PN4 – U28	YES	In good condition, looks the same, some exterior dirt. Durability (to daily use).	(Dirt mentioned but with no depreciative meaning, normal)	YES
	PP1 – U5	YES	In good condition, a bit darker. Appreciates good touch, beauty and elegance.		YES
	PP2 – U12	YES	Functional, good, durable, good condition. Appreciate lightness, easy handling.		YES
PP – Pen	PP3 – U19	YES	Writes very well. Appreciation of product in general, cork-gold combination.	(impression of point getting loose)	YES
	PP4 – U21	YES	Durability and resistance. Very good touch.		YES
	PP6 – U31	YES	Looks very well and good condition. Prefers natural things but product seems an aesthetic gift (nct to use often). Appreciation general product, aesthetics.	Bit of dirt from hands. Would change colour to avoid dirt. Loose point (not dependent on material - interior union with card).	YES BUT

PA – Bath mat dry

Table 1 – Synthesis of information related with appropriate use

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In PA – Bath mat dry the use of the material can be considered semi-appropriate (YES BUT) since a deterioration problem occurred but only with one product, with higher intensity and some careless use (high heels). Stepping in the mat is also dependent on bathroom layout and size, and one of the users suggested that it could be lifted after use from shower. Perhaps it is a bit delicate to lay permanently on the floor. Nevertheless, it has very strong characteristics mentioned by several users, such as pleasant tactility and comfort.

### PC – Soap dish

In the PC – Soap dish there was also a deterioration problem arising in the situation with higher intensity of use, in which a more aggressive soap was used (blue soap – flu), and at this 16 months moment use ceased; the product was starting to dissolve when returned. Apparently there is absorption of water (perhaps between the cork particles), since at that time PC1 was weighting twice as much as PC2 (278g and 142g respectively). Therefore, use of the material in this product is also considered semi-appropriate (YES BUT). Nevertheless, the other products are still in good condition, users are satisfied and express a general appreciation.

### PF – Fruit bowl

For the PF – Fruit bowl the use of the material is considered semi-appropriate (YES BUT) since stains were notice by most users. There was one problematic situation with several stains not totally removable, perhaps caused by a more ‘relaxed’ participant. Some users recommend applying a coating to avoid it; use of a mineral oil for protection was suggested in the packaging, but wasn’t applied since it was not provided (users not expected to buy it in reality). Besides that, the product is well appraised: it’s in good condition and aesthetically appealing.

### PK – Purse coins

For the moment, use of the material cork in the PK – Purse coins is considered semi-appropriate (YES BUT) since getting dirty is pointed out negatively in two out of three cases, and users suggest changing the finishing to avoid it. For another user this was acknowledged as ageing and aesthetically beneficial in previous moments. Nevertheless, users are all satisfied, and generally pleased with the functionality, durability and aesthetics of the product.

### PN – Wallet men

In PN – Wallet men, use of cork is considered appropriate (YES) since no negative issues were raised; slight dirt was mentioned but without a pejorative meaning (perceived as normal). In general, several users point out the durability of the product, good condition, pleasant touch and general aesthetic appreciation. Some users compare it with leather. And in one situation the participant observed that the material doesn’t scratches or wears out with use – instead, it wrinkles.

### PP – Pen

Application of cork in the PP – Pen can be considered appropriate (YES) since no material related problems occurred, users are satisfied, and most appreciate the durability, good condition, and aesthetic appearance of the product. There was only one observation of dirt, and suggestion to change the colour to avoid it. Good touch is pointed out by several users and others mention namely lightness and writing well. In one of the products the point got loose; this is a technical problem but not related with the material.

From the cases presented above, it can be concluded that these are relevant applications of the material, and there are opportunities for improvement in the situations of semi-appropriate (YES BUT) use of cork. The appropriate use of materials has the potential to contribute to increase product longevity, and consequently reduce resource consumption.

## **Evolution of product life-span in time**

In this section a preliminary evolution of product life-span is given: first, an overall evolution of the aggregated assessments; following there is a focus on the evolution of durability; and finally, product-user situations are presented to analyze the evolution of the five aspects over time.

Evolution of the aggregated assessments of the five aspects – overall results

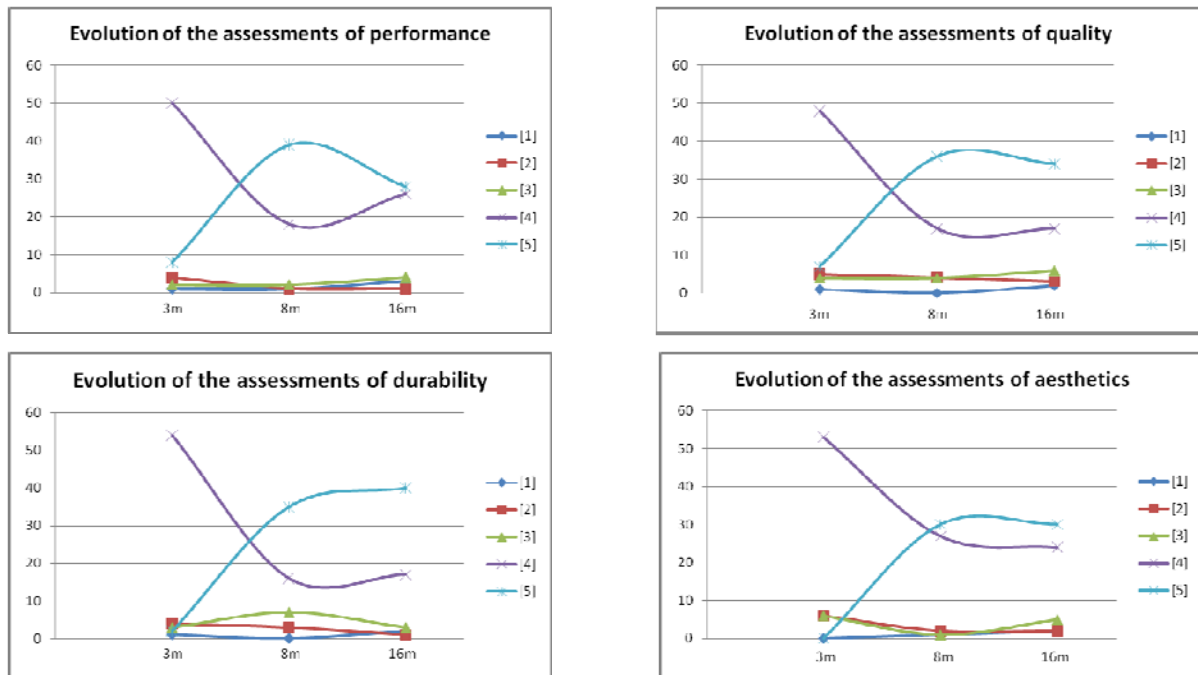


Figure 6 – Evolution of the aggregated assessments of performance, quality, durability and aesthetics

In the charts above it can be observed that the general evolution of assessments over time is positive; there was a general transition of ratings from [4] to [5], and which is more expressive in durability. In total, the number of negative or sufficient evaluations is low and evolving slowly, and it's non cumulative – cases returned at 3 months not accounted later. Consequently, there is a slight deviation in the total number of situations in each moment, also due to failure of information or interview. Attachment is not included for scale reasons (not expressive).

Evolution of durability – product cases for household and personal use

In these charts it is possible to compare how each user evaluates durability, and becomes clear that some negative situations are exceptions. While in PA – Bath mat dry, a wide range of assessments was given, in PK – Purse coins and PF – Fruit bowl it only ranges from score [4] to [5]. A high number of product-user situations enables diversity, and perhaps a wider range of assessments; it is curious to notice how the 3 users of PA1 evaluate its durability differently. A few evaluations are hidden behind others or missing. In PC – Soap dish it is noticeable how the problematic situation of the returned product is detached from the experiences of others. In PN – Wallet men and PP – Pen there is a downwards curve by the same user (U21), which does not represent depreciation but an 'undervaluation', also due to the early moment; in the last interview this user explicitly mentioned that doesn't give [5]'s.

From the cases presented, despite some exceptions mainly in household products, it can be concluded that the evolution of durability is positive in most situations, and that scale is enriching. In a general way it seems that 16 months is already a good time-span for users to evaluate the durability of these products confidently, since many have already expressed the highest score when appropriate.

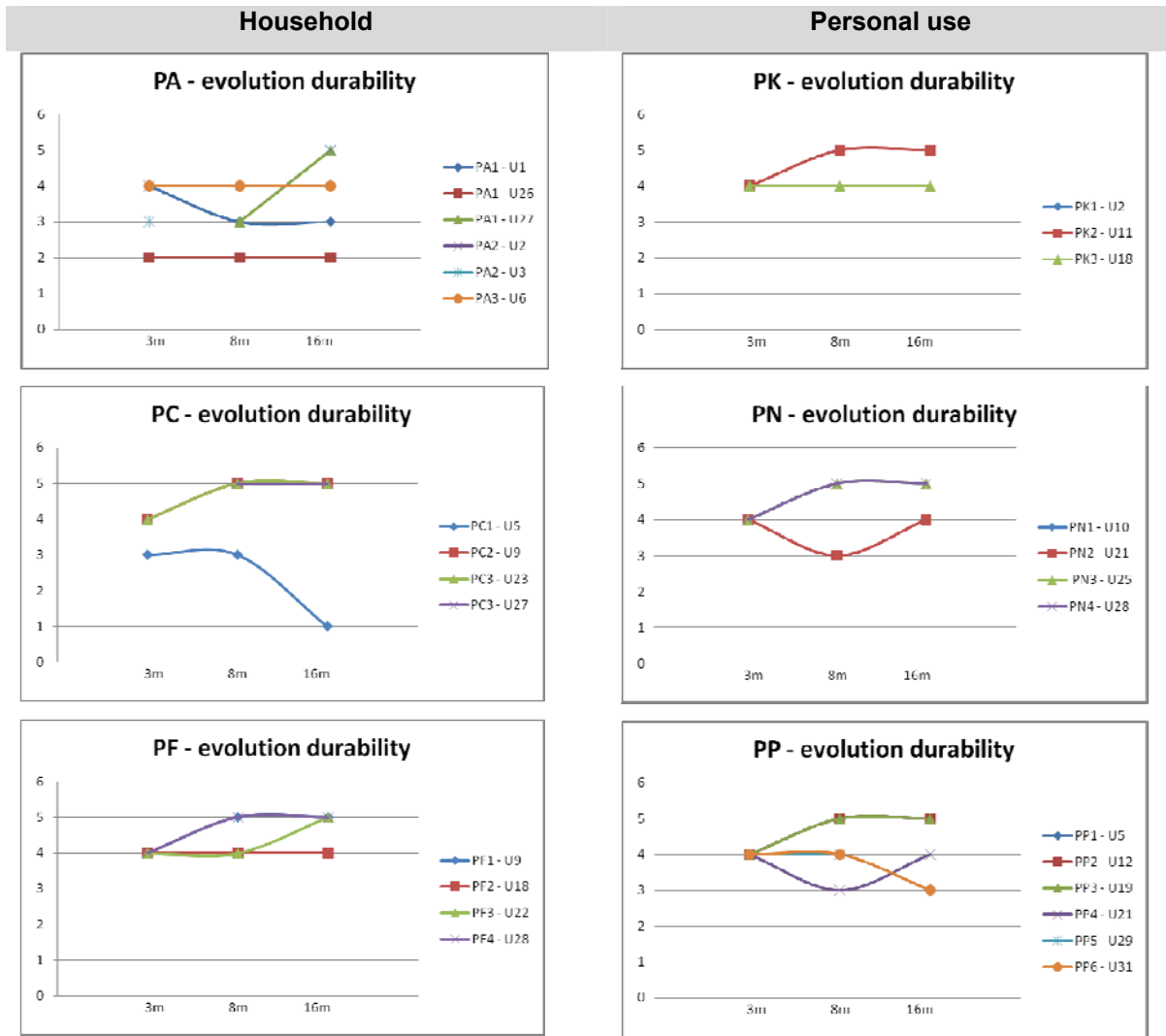


Figure 7 – The evolution of durability – product cases for household and personal use

**Evolution of the five aspects in time – product-user situations**

The situations can generally be classified as positive stable (most) or problematic unstable. Some examples of each are given with succinct observations. Even though there are some commonly occurring curves, for the moment, more specific or detailed relations are not noticed yet (e.g. if two aspects evolve together).

Problematic unstable cases

Evaluations of the same product by different users can be substantially different, such as in PA1 used by U1 and U26 (living together). In comparing the two charts it can be noticed that while both acknowledge something ‘wrong’ in the first moment, over time, this became much more significant and expressive for user 1, and to whom the product life-span is already over; in contrast, user 26 is still attached and willing to continue using the product. Another noticeable issue is that when a problem occurs, it often affects more than one aspect, sooner or later; in PA1 – U1 and PC1 – U5, both at end-of-life, almost every aspect became negative.

In the case of PC1 the evolution of quality is non-linear due to evaluation of the intrinsic quality of the material (at 8m: not a cork problem; it can be the size of the granules, the binding, the application, but not cork itself). And durability is not affected early since the structural failure as a consequence of deterioration was not expected (“the product can last a whole life but ugly” U5).

In PF2 – U18 the stains resulting from rotten fruit are mainly perceived as a quality problem, and which later also starts to affect performance, since doubts arise about placing new fruit on top of stains, in particular fruit to be eaten with the peel. Also in this case, durability is expected to be high



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(no expectation of breaking or dissolving in consequence of the stains). Even though the stains affect the integrity of the product, this is not reflected in the assessment of durability, which seems to be mainly perceived as a whole physical or mechanical integrity of the product (absence of failure). And while attachment seemed compromised in the beginning, is now in a stable position, perhaps due to high aesthetic appreciation (as new; aesthetics hidden behind attachment).

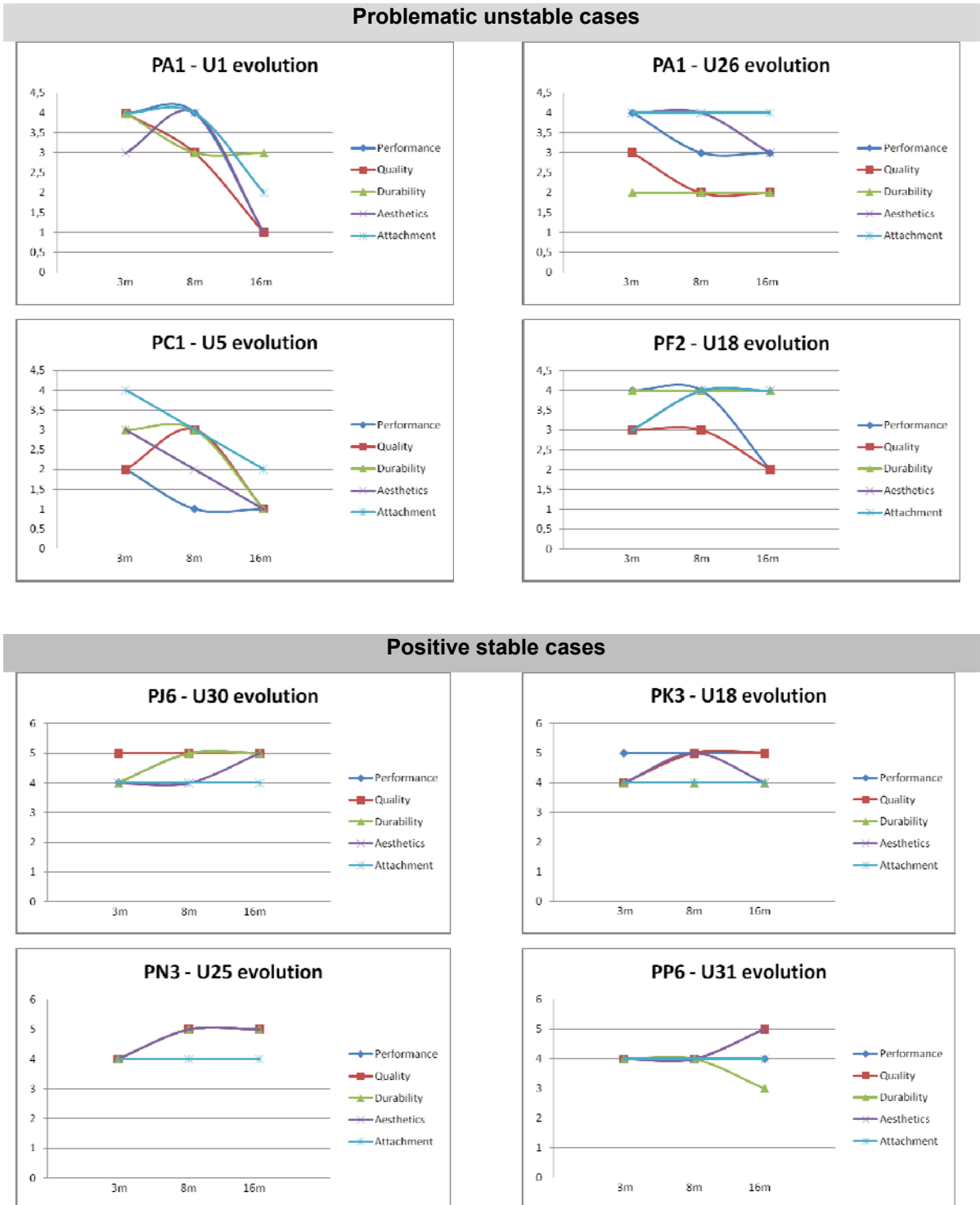


Figure 8 – Illustrative examples of problematic unstable cases and positive stable ones (common curves)

### Positive stable cases

In these cases there are almost no negative assessments, and there is often an upwards change movement after the 3 months moment, eventually more moderate (first moment and qualitative). Attachment remains constant due to the scale difference, but normally the evolution is either positive or negative, and coincident (PN3 – U25; the most common curve) or not (PJ6 – U30; PJ – Key chain, included here to show the curve). In comparing these two cases, it is interesting to observe that even though the assessment of all parameters is the same at 16 months, the path is quite different. In PJ6 – U30 the aspects ascend gradually, and aesthetics later with the ageing (darkening) of the product. In PN3 – U25 all the aspects evolve together. In PK3 – U18 aesthetics also ascends with the ageing (darkening) of the product at 8m, and then descends afterwards as it then appears to become a bit dirty; for these users the darkening is ageing not dirt. PP6 – U31 illustrates a less common situation in which the durability of the product is affected due to a specific issue (point of pen got loose), but not yet rated negatively.

### **Discussion**

The approach has high diversity of products, cork materials and topics; this generates large amounts of information, complex to manage, and which has to be partially overlooked to accomplish reasonable levels of synthesis; though, it is considered appropriate for the explorative scope of the research.

Determining the appropriate use of the material is not straightforward or easy; scale provides diversity and confidence and is therefore important. Even though the moments are the same for all cases (constant), it is difficult to compare situations due to differences in the intensity of use, or even in the context of use (e.g. people eating different fruit).

Concerning this preliminary exploration of the evolution, even though some differences were noticed, there was the expectation of observing something else, or 'patterns'; more data to reason upon and eventually generalize. It seems that learning happens mostly from the cases that fail, and which are not that many yet; perhaps it is early. These are good results for cork (material, sector), but not so enlightening for other research purposes. Nevertheless, this evolution perspective seems relevant for studying the longevity of products.

Additionally, at this moment and before, when designing and implementing the study, it was felt by the researcher a lack of significantly close literature for comparisons and discussions; to 'build upon' the work of others.

### **Conclusions**

From the results accomplished so far, it can be concluded that this research approach provides important, enriching and original knowledge, contributing to enhance the understanding of the phenomenon of product life-span from a design perspective. For the moment, in most product-user situations everything is fine; products are still being used, satisfaction is high (92% Yes), and it can therefore be concluded that the life-span of the cork products is very good.

In some products (mainly household), occasional problems arose in specific situations; these were often the ones with higher intensity or a more careless use. As such, some evaluations are negative, and the initial appropriate use of the material is lowered to a moderate level. Nevertheless, overall, in the products being studied, the application of the material is considered positive for the moment.

The main aspects affecting the appropriate use of the material negatively, and consequently life-span, are related with deterioration and surface changes. Other non-material issues influencing the longevity of products were identified, but are not detailed in this paper due to focus on appropriate use and evolution.

From a more general perspective, it can be concluded that most of the issues arising are material related, and which appears to be independent of the focus on the material. This seems to emphasize the importance of material aspects when studying product life-span, and the relevance of addressing the appropriate use of materials, considering the significant potential in extending product longevity.

The main positive aspects identified contributing to appropriate use are: good condition, durability, aesthetic appreciation, pleasant tactility, functionality, and general appreciation of the cork products.

Concerning the evolution of the assessments, there was in general a transition from score [4] to [5], and this is more expressive in durability. The assessments and evolution of this aspect, show that users are well satisfied with the durability of the cork products, that it is very good for the moment.

From the analysis of the evolution of product-user situations, some common curves were identified for the positive stable cases. On the other hand, in problematic unstable cases, besides differences in ratings by users of the same products, it is possible to observe that often, even though the occurrence of a specific issue (e.g. deterioration) has repercussions in several parameters, this may not happen simultaneously.

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# Standardization of Life Cycle Assessment to Ensure Transparency in Product Labeling

Tobias C. Schultz, SCS Global Services

Emeryville

USA

## 1. Introduction

Businesses, consumers, government agencies and institutions are increasingly seeking to understand the full life-cycle environmental and human health impacts of products and services prior to purchasing, in order to make informed choices that have the greatest environmental benefits with the fewest trade-offs.

Over the past decade, there has been an explosion in the number and type of ecolabels. Some of these ecolabels address narrow, single attributes, such as recycled content, BPA-free, air quality or biodegradability. Others are intended to cover a multitude of environmental attributes, such as the Business and Institutional Manufacturer Association (BIFMA) “level standard for furnishings and the Forest Stewardship Council (FSC) responsibly managed forest certification.

There has been little consistency in the manner in which these ecolabels have been developed, and hidden environmental trade-offs are often overlooked. Even the most comprehensive attribute-based eco-labels sometimes overlook the way in which compliance with the criteria may lead to unintended negative environmental consequences. As a result, users have been left with the difficult task of determining which ecolabels to trust.

In response, new solutions are being sought that can cut through the myriad ecolabel approaches to deliver clear environmental answers. The current trend is to develop disclosure labels based on life cycle assessment (LCA) to satisfy this need. As these labels come into vogue, it is vital that their results reflect a universally accepted list of impact categories, and that they rely on comparable calculation methods. ISO 14044, the cardinal standard behind LCA, provides the general framework, but the devil is in the details.

A new standard being developed under the American National Standards Institute (ANSI) process is tackling this challenge, and promises to make LCA-based product labels more comprehensive and consistent than ever before. This standard provides a common, comprehensive set of impact category indicators and calculation methods that ensure robust measurements sufficient to support decision-making and product ecolabels, incorporating methods developed and tested over the past 20 years. The standard has been developed under an open, multi-stakeholder committee process with members from industry, academia, and the environmental community. It has incorporated significant stakeholder input, and is now undergoing public comment. It fulfills and complements the intent of the international standards, ISO 14044 and ISO 14025.

## 2. Basing Ecolabels on Life Cycle Assessment

### 2.1 Challenges

LCA-based disclosure labels hold tremendous potential for communicating the relative environmental impacts of products and services, provided that the scientific underpinnings are sound, the labels are clear, and the users can access further details about the LCA study. However, in an effort to be pragmatic and understandable, early attempts to create LCA-based disclosure labels have tended to oversimplify information, report misleading results, and omit crucial information.

This is due in part to ambiguities in the ISO 14044 framework, which provides detailed guidance for the scoping and life cycle inventory (LCI) phases of the LCA process, yet only provides general

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guidance on conducting life cycle impact assessment (LCIA), which lies at the heart of environmental labelling. It leaves details about methods for calculating category indicator results to be used in ecolabels to others to fill in.

In addition, even where the ISO 14044 standard has been quite specific, LCA practitioners have not always followed its guidance, or have misunderstood its intent. Several common mistakes in LCA studies lead to misleading results in their associated ecolabels, and can even lead to overt “greenwashing”:

- Failing to address all human health and environmental impacts.
- Reporting results that inappropriately aggregate distinct environmental impacts.
- Ignoring the environmental relevance of results.
- Selecting calculation methods arbitrarily, to portray products in the best possible light.

To avoid confusion, LCA-based ecolabeling should be built on a comprehensive set of impact categories that can transparently communicate all of the environmentally relevant impacts and hidden trade-offs associated with a product or service, using a consistently defined calculation methodology.

### 2.2 The LCA Standard Being Developed under the ANSI Process

In grappling with these issues, government agencies, companies and practitioners in the US have recognized the need for a supplemental standard to complement the ISO 14044 and fulfill its original intent, focussing on those areas not fully fleshed out in the ISO 14044 standard, and addressing the requirements to support robust environmental labelling and product comparisons. The new draft standard, LEO-SCS-002, accomplishes this goal, by requiring LCAs that support public claims and declarations to:

- Fully Incorporate the Environmental Relevance Provisions of ISO 14044
  - Addresses all applicable impact categories
  - Requires regional and site-specific characterization, with stressor and environmental characterization factors, providing results which are representative of impacts which are occurring on the ground.
  - Applies units of measure scaled to biophysical impact levels
- Ensure that Environmental Mechanisms are Delineated
  - Separates impact categories by environmental mechanism
- Generate Complete Life Cycle Impact Profiles
  - Details calculation algorithms for category Indicators
  - Supports direct comparative assertions
  - Supports comparative Type III ecolabels

In addition, it creates a pragmatic framework that can be applied broadly in support of ecolabeling efforts by:

- Streamlining the process for creating Environmental Product Declarations
  - Defines product categories by functional unit — fewer Product Category Rules needed
  - Simplifies PCRs by specifying LCIA requirements
- More fully describing the Iterative Assessment Process
  - Supports streamlined data collection through successive iterations

Together, these provisions can help prevent “greenwashing” and reinforce the value of LCA-based disclosure labels.

The standard is being developed under the American National Standards Institute (ANSI) process, being facilitated by the Leonardo Academy, a non-profit standards development body. This standard, currently undergoing public review, has generated considerable interest, with input from a wide range of stakeholders, including 446 comments from 38 different organizations. Committee members include

participants from major industry associations, globally recognized commercial product companies, state and federal government agencies, and leading environmental non-profit organizations.<sup>1</sup> Issues discussed and lessons learned from this process can be useful in informing similar ecolabeling initiatives in Europe and elsewhere around the globe.

### 3. Drilling Down into the Details

#### 3.1 Addressing All Human Health and Environmental Impacts

The draft standard provides detailed guidance regarding the selection and exclusion of impact categories in an LCA study, beginning with a “hot spot” analysis to highlight major contributors to category indicator results, and to identify known major impacts in the supply chain that are generally overlooked using conventional LCA models. Twenty-five “general” impact categories are listed in the main body of the standard, representing major impacts to the environment and human health that have been observed to occur on an important scale worldwide. Of these general impact categories, only some are likely to be applicable to a particular product; these are termed “core” impact categories. The standard provides guidance on identifying these “core impact categories.”

Additionally, multiple category indicators may be identified within an impact category on a site-specific basis. The standard requires that all distinct category indicators must be identified within these impact categories. For instance, when Key Species Loss is identified as a core impact category for a system, separate category indicators will typically be required for each key species affected (see Figure 8). The LCA practitioner determines the final list of category indicators included in the impact profile of an industrial system, based on these guidelines.



Figure 8. An LCA study of the Pacific Lumber Company (see Section 5.1) identified 16 key species that were impacted; the three shown here (from left to right) are the Northern spotted owl, Marbled murrelet and Pacific Fisher.

#### 3.2 Using Accurate and Environmentally Relevant Measurements

Together, the category indicators results for the core impact categories form the impact profile of a product. The environmental relevance of a category indicator reflects the degree to which indicator results reflect the actual impacts occurring on the ground; when environmentally relevant category indicators are chosen for use, results will accurately reflect a product’s contribution to the impacts. However, the availability and uncertainty of environmental characterization data ultimately limit the degree of environmental relevance that can be achieved for a selected category indicator, and results of the impact profile are constrained by what can be measured.

The category indicators specified in the standard are both environmentally relevant and accurate, and characterized in terms of four parameters related to the environmental effects of stressors on the environment:

- Temporal effects, including the duration, persistence, or residence time of emissions.
- Spatial effects, accounting for the geographic area affected.
- Intensity of the effect, including the severity of damage, depletion, or disturbance to a specific receiving environment.
- Reversibility of the effect, accounting for the degree to which established

<sup>1</sup> For more information on the LEO-SCS-002 standard, see <http://www.leonardoacademy.org/programs/standards/life-cycle.html>

- human health and/or environmental threshold(s) have been or are projected to be exceeded.

### 3.3 Using the Iterative Process to Steer Data Collection Efforts

The use of a complete set of environmental impacts and environmentally relevant measurements allows a precise and complete measurement of impacts arising from each “unit process” involved in the production of a product. Through successive iterations of analysis, typically 5-10 “key” unit processes can be identified that contribute to almost the entire impact profile of a product, out of dozens or even hundreds that may be involved in its production.

In the iterative process, the “key” unit processes are first identified using LCA modelling with secondary data; primary data collection efforts are then targeted to only those key unit processes. While ISO 14044 mentions the iterative process, the draft standard provides detailed guidance on how it works, enabled by the sophisticated metrics it requires, and building on work by the Danish Ministry of the Environment and the European Commission Joint Research Committee. It also provides for data quality assessment parameters that address both the inventory data and the impact assessment data.

In summary, the results generated in accordance with ISO 14044 and the draft standard provide comprehensive, accurate results, while simultaneously streamlining the data collection process to remain pragmatic for use.

## 4. Ecolabels Derived from the Draft Standard

By requiring that a complete set of core impact categories related to a product be assessed using accurate, environmentally relevant measurements, the draft standard will help practitioners and users alike ensure that the LCA results used in an ecolabel are meaningful and representative of the true impact profile of the product.

The standard includes specific provisions for a wide range of LCA-based claims, declarations and footprints, speaking to overall environmental performance, and environmental performance related specifically to climate change. Among this latter group are labels related to climate change in the Arctic region, made possible by the site- and region-specific characterization provisions of the impact assessment phase.

- Comparative and non-comparative environmental declarations
- Environmental System Declarations
- Environmentally Preferable Product Claims
- Carbon Footprint Profile
- Carbon Footprint Reduction
- Carbon Neutrality
- Net Carbon Storage Product
- Arctic Climate Footprint
- Arctic Climate Neutral

## 5. Applications of the Draft Standard

The scientifically robust framework of the draft standard supports a level of decision-making regarding procurement strategies and product design that is not achievable using conventional LCA results. Applications include differentiating between the impacts of different sources of raw material, such as wood, and supply chain management to optimize environmental performance. Two applications are summarized here.

### 5.1 Robustly Assessing the Environmental Impacts of Forest Management

To aid in procurement, conventional LCA has often been used to compare the impacts between competing materials, such as wood and steel. In reality, the impacts associated with a single material choice can vary dramatically between different sources. This is demonstrated by a recent LCA study



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conducted in accordance with the draft standard, which compared the impacts of two different forest management operations practiced on the same land by two different companies. The LCA showed dramatically different impact levels.

The assessment focused on impacts from sequential operations in a 209,000-acre redwood forest in North America: Pacific Lumber Company (PALCO) and Humboldt Redwood Company (HRC). The impacts were investigated for two time periods: from 2001-2007, when PALCO operated in the forest, certified by the Sustainable Forestry Initiative (SFI); and since 2008, when HRC began operations, certified by the Forest Stewardship Council (FSC).

The impacts accumulated during the PALCO management period, from 2001-2007, included:

- Depletion of Wood Resources. 296 million board-feet of wood resources were depleted.
- Cutting of Old Growth Trees. 27,000 old growth redwood and Douglas fir trees (greater than 5 ft. in diameter) were cut down, including trees over 1,000 years old. This damage cannot be recovered within a timescale relevant to human lifetime. Legacy impacts of forest management practices under the same ownership included the cutting of an additional 360,000 old growth trees.
- Disturbance to Forest Ecosystems. Clear cutting practices disturbed 32,000 acres of mature second growth forest, replacing it with a 35-year-old even-aged managed "tree farm." Legacy impacts of forest management practices under the same ownership (1986-2001) included disturbance of an additional 34,000 acres of mature second growth forest.
- Impacts to 900 miles of Rivers. Legacy impacts under the same ownership prior to 2001 included severe disturbance to nearly 900 miles of rivers in 7 major watersheds. From 2001-2007, regulations prevented further disturbance; however, recovery practices were minimal, and all rivers remained at a high level of disturbance.
- Disturbance to Habitats of Four Critical Species. Loss of suitable habitat for 4 critical species, including: Northern spotted owl (32,000 acres); Marbled murrelet (27,000 trees), Pacific Fisher (27,000 trees), and Sonoma tree vole (9,500 trees). Legacy impacts under the same ownership included additional disturbance to these four species, as well as disturbance to suitable habitat for twelve other key species.
- Climate Change Impacts and Global Emission Impacts. Loss of forest carbon storage resulting in 4 million tons of net CO<sub>2</sub> emissions released to the atmosphere. Legacy impacts under the same ownership prior to 2001 led to 21+ million tons of net CO<sub>2</sub> emissions.
- Worker Exposures to toxic herbicides. Annual spraying of 1,000 pounds of atrazine (a known endocrine disruptor) and 120 lbs. of 2,4-D (a probable carcinogen), applied by backpack application without proper workers protection.

By stark contrast, the Humboldt Redwood Company has practiced restorative forestry since 2008, resulting in the following improvement milestones on the same parcel of land:

- Forest Carbon Storage Gain. 1 million tons CO<sub>2</sub> removed from atmosphere due to increases in carbon storage from net regrowth of the forest, based on high growth-to-harvest ratio. An additional 5 million tons of CO<sub>2</sub> sequestration projected in next 20 years, equivalent to removing one million cars from the road.
- Halting cutting of old growth trees. No old growth redwood or Douglas fir trees have been cut, and the company has committed to never cut old growth trees.
- Wood Resource Accretion. Net regrowth under timber management plan will result in the accretion of 150+ million board-feet.
- Recovery of disturbed rivers. Up to 900 miles of rivers in seven major watersheds are projected for recovery in the long-term.
- Habitat recovery for up to 13 critical species. Recovery practices will eventually result in the recovery of over 70,000 acres of nesting habitat for the Northern spotted owl, and additional habitat recovery for 12 other species.

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- Long-term recovery projected. Over the next century, up to 66,000 acres of forest will be restored to a mature redwood and Douglas fir forest

The LCA highlights the radically different impacts which can arise from the same material choice.

### 5.2 Supply Chain Management Tool

The use of the LCA framework of the draft standard supports the optimization of resources used within the supply chain to achieve environmental performance improvement goals:

- The draft standard includes guidance for defining benchmarks, which can be used to differentiate among suppliers with different levels of environmental performance, and to spur continuous improvement in the supply chain.
- By including a comprehensive set of impacts, measured in a scientifically accurate fashion, users can identify the most cost-effective opportunities for impact reduction, across a breadth of impacts.
- Guidance and requirements for “hot spot” assessment are provided, supporting the identification of major impacts to the environment or human health occurring in the supply chain. These “hot spots” can present a risk to corporate branding and image. Once identified, mitigation efforts can be instituted and tracked.

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## **Benefits and Difficulties for Industry when Designing for Sustainable Behaviour**

Anneli Selvefors

PhD student, Design for Sustainability

Design & Human Factors, Product and Production Development

Chalmers University of Technology,

SE-41296 Gothenburg

Sweden

Sara Renström

PhD student, Design for Sustainability

Design & Human Factors, Product and Production Development

Chalmers University of Technology,

SE-41296 Gothenburg

Sweden

Anna Viggedal

MSc, Industrial Design Engineering

Chalmers University of Technology

Gothenburg

Sweden

Rebecka Lannsjö

MSc, Industrial Design Engineering

Chalmers University of Technology

Gothenburg

Sweden

Ulrike Rahe

Professor in Industrial Design

Design & Human Factors, Product and Production Development

Chalmers University of Technology,

SE-41296 Gothenburg

Sweden

### **Abstract**

The research field of Design for Sustainable Behaviour (DfSB) suggests strategies for promoting more sustainable use of products. The DfSB methodology thus provides opportunities for companies to further reduce their products' environmental impact and differentiate on the market, still DfSB is not yet systematically applied in industry. This paper highlights benefits and difficulties that companies face

when applying design strategies for sustainable behaviour in the product development process. A master thesis project at Electrolux is used as a basis for discussion. In summary, besides the environmental gains, DfSB can spur innovations that fit users' implicit needs and thus create potential for increased profitability. Nevertheless, companies need to extend their competence within DfSB and methodologies that facilitate the implementation of DfSB in companies' current product development processes should be developed.

### Introduction

To reduce products' environmental impact, the field of eco-design has hitherto mainly focused on production and end-of-life phases in the product life cycle. However, for many products, the use phase is the largest contributor to the total environmental impact of a product. For new refrigerators the electricity demand during the use phase constitutes 80 to 90% of the total environmental impact (Rüdenauer and Gensch, 2007). The energy demand of products during the use phase can be seen as a combination of *intrinsic losses* dependent on the engineering design of the product and *user-related losses* caused by inefficient use patterns (Elias et al., 2009). With more efficient technology, the intrinsic losses of products can be reduced and at the same time the user-related losses will increase in importance as they increase in percentage of total energy consumption (ibid.). The research field Design for Sustainable Behaviour (DfSB) focuses on the user-related losses and suggests strategies for promoting more sustainable use. A number of different design strategies have been proposed, such as giving users feedback or scripting the most sustainable user behaviour (Lockton et al., 2010, Zachrisson and Boks, 2010, Wever et al., 2008, Lilley, 2009). Research has highlighted the potential for design interventions to influence behaviour and studies have reported resource savings up to 20% due to adoption of changed use patterns (Darby, 2006, Fischer, 2008). In addition, high user acceptance regarding some DfSB products has been noted, indicating that consumers are willing to embrace new behaviours if equipped with the right tools (Lidman et al., 2011). Thus DfSB provides opportunities for companies to further reduce their products' environmental impact, but unfortunately design strategies for sustainable behaviour are not yet systematically applied in industry. To better understand why this is, this paper aims to highlight benefits and difficulties that companies face when applying DfSB in the product development process. A master thesis project carried out by industrial design engineering students in cooperation with Electrolux is used as a basis for discussion. This paper reports on the experiences of the people involved in the project in relation to the product development process and to the final result. The project and its result are briefly described, followed by reflections on the difficulties and benefits industry could experience when designing for sustainable behaviour.

### A Refrigerator Concept for Sustainable Behaviour

The project was initiated by two master students from the Industrial Design Engineering programme at Chalmers University of Technology, Sweden, together with the research group Design for Sustainability at Chalmers and carried out in cooperation with Electrolux. The aim of the project was to develop a refrigerator concept for the near future that enables users to adopt sustainable behaviours to reduce the overall environmental impact of the refrigerator. Electrolux AB is a Swedish global company with the flagship brand Electrolux, producing white goods and small appliances for personal and professional use. Electrolux has a strong user focus and a notable sustainability profile, producing appliances with high energy efficiency ratings. The master thesis project was carried out at Electrolux's industrial design centres in Stockholm, Sweden, and Porcia, Italy, in multi-disciplinary work environments where industrial designers, graphic designers, and user experience specialists work together.

The master thesis project lasted five months, with full-time engagement of the two master students. They worked independently, but got feedback regularly from employees at Electrolux and their academic supervisors. The design process, summarised in figure 1, followed a previously outlined DfSB process (Selvefors et al., 2011). Initially, the master students defined a persona, based on one of Electrolux's well-defined target users, to represent the target group. Thereafter the master students chose to focus their user research on refrigerator use situations at home to identify relevant *target behaviours* (a term used by e.g. Lockton et al. (2010)). They performed a user study focused on peoples' refrigerator use, their attitudes towards sustainability and plausible reasons for unsustainable behaviours linked to refrigerator use. The study consisted of both quantitative and qualitative methods

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and was divided into three parts; an online survey with 133 respondents from 14 different countries, self-reflective exercises with five persons representing the target group, and finally a focus group where the same five persons were gathered to further discuss the topic. The findings indicate that users often have a low understanding of how different actions influence energy consumption and food durability, e.g. they have poor understanding of what effect the placement of warm food in the refrigerator has on the energy consumption. In addition, people have limited knowledge of how to preserve food appropriately and they often do not know what they have in their refrigerator due to insufficient overview, resulting in food waste. Based on attained insights and input from Electrolux, two target behaviours were chosen and design concepts were developed in an iterative process using DfSB strategies until the final concept was formed. The design process will be discussed further in the section Reflections.



Figure 1. Design process.

### Refrigerator Concept

The project resulted in a counter-high refrigerator concept with four drawer-based compartments allocated to three different temperature zones, see figure 2. It was designed for Electrolux's high-end product portfolio to strengthen the Electrolux brand. Several DfSB strategies were applied to facilitate and support behaviours limiting wasteful consumption of food and energy during use. The design itself enables and encourages users to minimise resource wastage: the four compartments are customised for preserving different types of food and thus prolong the lifespan of the food; the drawers are equipped with a soft-close function preventing leakage of cold air; the "EatSoonZone" highlights food that is soon to go off, thus encouraging the users to eat it before it has to be thrown away, see figure 3. Additionally, users are advised on suitable temperature zones for different foodstuff and given a good overview of the content to prevent users from forgetting what food they have, see figure 4. Furthermore, since energy is saved when food is thawed inside the refrigerator, this is promoted through the design. When frozen food is placed on the interactive top surface, see figure 5, a suggestion of a suitable refrigerator compartment is given along with an indication of the time it takes to thaw the food. Similarly, when cooling food, an indication is given of the time it takes until the food is cold enough to be placed in the refrigerator, see figure 6. The top surface also doubles up as a workbench offering free space when loading and unloading groceries. By simplifying food and cooking related activities and facilitating food preservation, the concept makes it natural to act more sustainably.

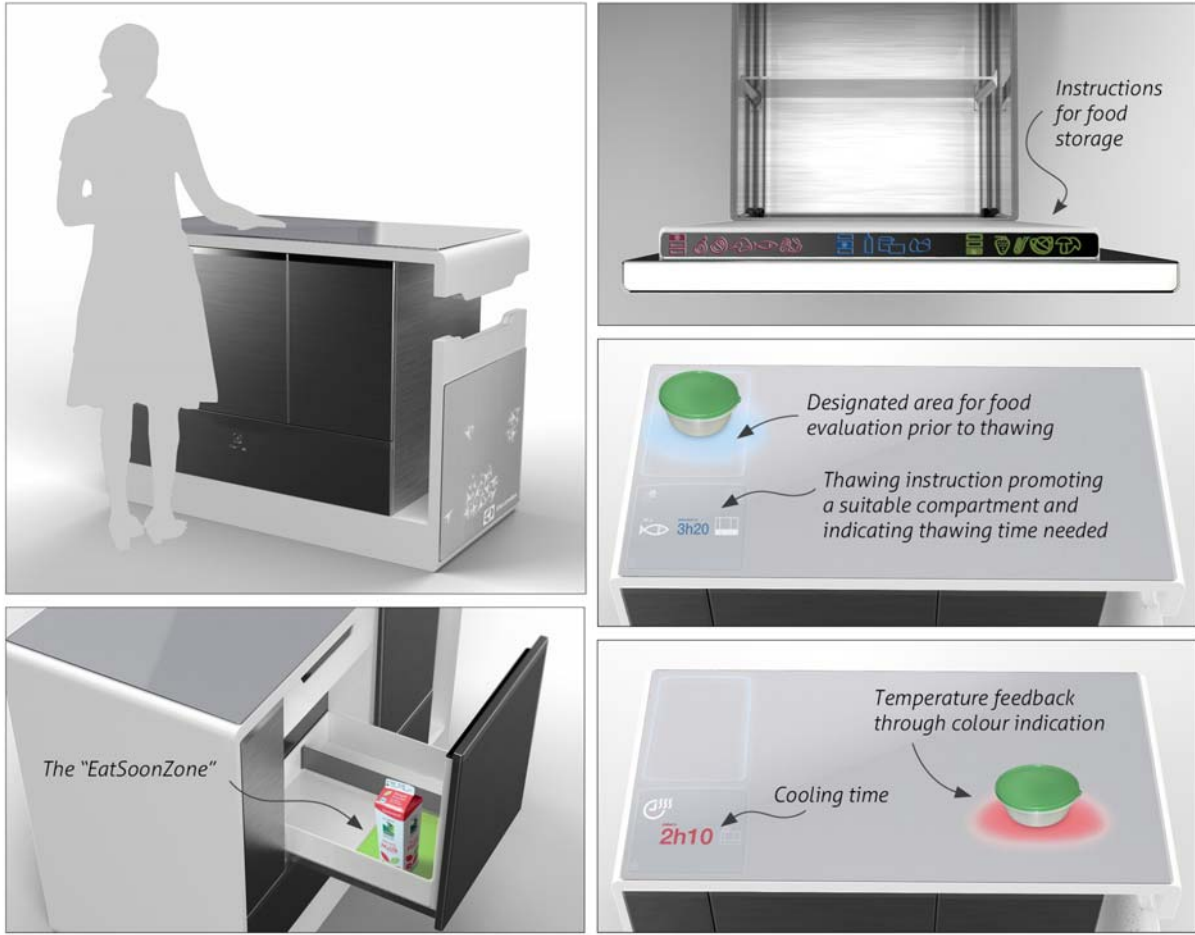


Figure 2: The refrigerator concept.

Figure 3: The “EatSoonZone”.

Figure 4: Top view of drawer.

Figure 5: Instructions for food thawing.

Figure 6: Food cooling.

## Reflections

### Difficulties

The introduction of DfSB to Electrolux raised some initial concerns, one of them being the question of profitability: Will the customer be willing to pay for the additional development costs of a DfSB product? In an effort to address this issue and make the product worth the higher cost, the master students strived to combine design features encouraging sustainable behaviours with innovative functionality fulfilling implicit user needs. Notably, after reviewing the final concept, the design director at Electrolux saw potential for profitability and is now interested in exploring how the methodology can be incorporated in future projects.

To engage in a DfSB product development process when re-/designing a product, companies are advised to look beyond the sustainability aspects of the product itself and explore use situations to identify target behaviour/-s to address during the development process. Choosing target behaviour/-s is challenging and techniques have been developed to analyse use situations to pinpoint behaviour/-s with the highest resource saving potential (Elias et al., 2009, Thorander and Karlsson, 2011). But which use situations are relevant for a company to investigate? As illustrated in figure 7, there are several levels of user activities to consider: direct use of the product, user activities involving the product, and user activities affected by the product. It is appropriate to first address direct use of the product but other activities influenced by the product might have higher environmental impact. Studying activities involving the product, e.g. occasional use of a refrigerator during cooking, can provide insights on the product’s effect on resource consumption during everyday activities. Further

on, studying more peripheral activities affected by the product in a wider sense could give innovative ideas for radical changes.

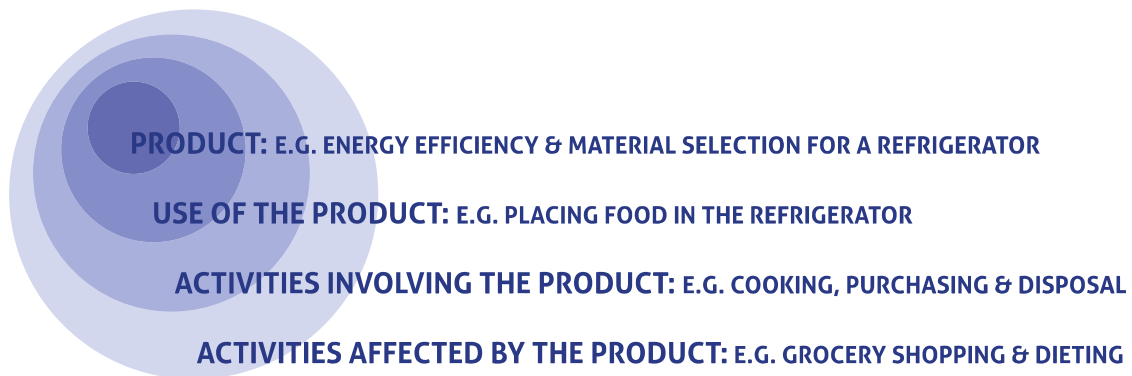


Figure 7: Three levels of user activities influenced by a product.

Time limitations and budget constraints make it difficult to carry out comprehensive studies covering all use situations attributed to the product. Consequently, the research must be limited to a manageable level. During the project, the criteria considered for choosing use situations were the relevance to the product, to Electrolux’s business strategy and to the target user. The master students limited the research scope to refrigerator use at home, see figure 8. The broad focus enabled them to carry out a thorough analysis of user activities, mental models and food habits resulting in interesting insights regarding the environmental impact of behaviours related to refrigerator use.

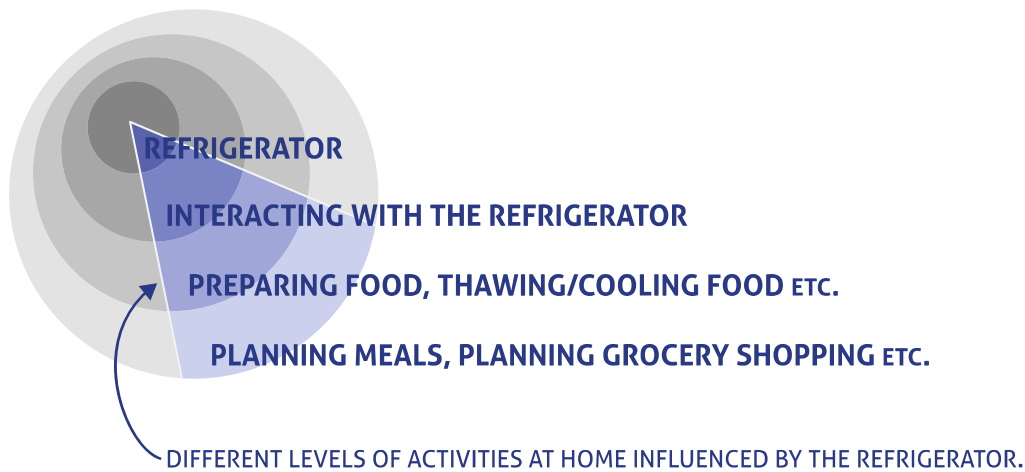


Figure 8. The chosen use situations.

When analysing the studied activities and behaviours, the master students used a set of criteria to assess and choose target behaviours. First, resource saving potential was considered and efficient thawing/cooling and durable food preservation were identified as two promising target behaviours to reduce both energy and food wastage. The master students also considered the behaviours’ relevance to the company’s strategic plan and future vision, whether or not the behaviour suited the company’s brand and core values, and if it could intrigue and attract the target user. By choosing target behaviours based on these grounds, the master students anticipated that the final design concept would provide gains for the environment, the company, and the user. During evaluation of concepts, feedback from Electrolux ensured that the chosen concept suited the company’s vision and brand. In addition, to evaluate the concept from a user perspective the persona’s characteristics and lifestyle were considered to assess how different DfSB features would be used and a focus group were held to assess the overall attractiveness of the final result. A more objective way to assess the

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effectiveness and acceptability of DfSB features is to evaluate prototypes with actual users (Lidman et al., 2011). Unfortunately, to carry out a thorough evaluation assessing long-term effects requires time, functional prototypes and many test subjects, resulting in a costly procedure. As an alternative, collections of good examples could be used as guidance, e.g. the Design with Intent toolkit (Lockton et al., 2010) and the website Design-Behaviour (Lilley, n.d.).

The design director at Electrolux stated that for future use of DfSB, a revision of Electrolux's current product development process would be required to enable a more DfSB-centred approach.

As seen in the project, choosing use situation and target behaviour/-s after assessing selection criteria from both an environmental, corporate, and user perspective, as illustrated in figure 9, can facilitate the decision making process. Furthermore, a concept's potential of becoming a commercially successful DfSB product can be assessed by also using objective product evaluation criteria that takes the environment, users' perception of the product and user needs into account. However, unfamiliarity with DfSB amongst company employees can make it difficult to apply supportive DfSB methods throughout the development process. The design director indicated that they do not have the knowledge and competence at Electrolux to fully apply DfSB methodology today.

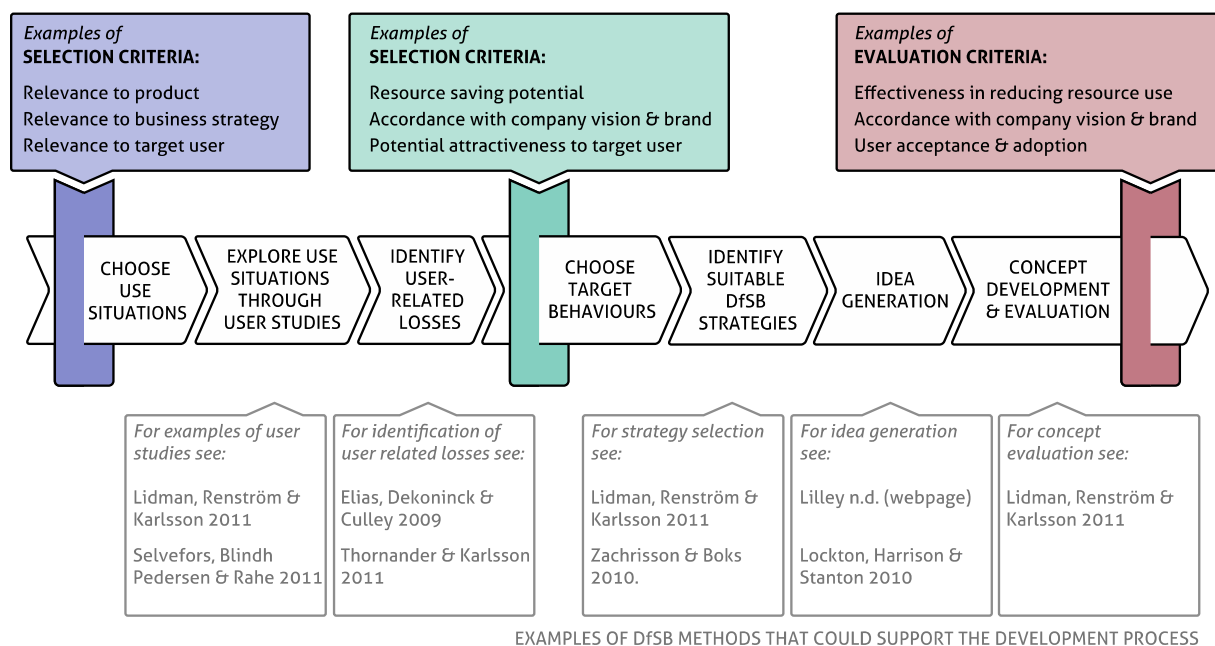


Figure 9. Examples of selection and evaluation criteria.

## Benefits

Compared to User-Centred Design processes, focusing on explicit and implicit user needs, DfSB adds a behavioural perspective to the product development process, focusing on user needs but also on peoples' resource consumption during interaction with products. This perspective enabled the master students to gain new and different insights on refrigerator use and resource consumption, in comparison to conventional User-Centred Design research. The insights facilitated the development of innovative functionality and, according to the design director at Electrolux, an equivalent result would not have been attained in a traditional design process. DfSB's potential to spur innovations that fit the target users and have the potential to reduce resource consumption was, by both the master students and the Electrolux employees, found to be one of the greatest advantages of DfSB.

Some of the employees at Electrolux, after being introduced to the DfSB, considered DfSB-thinking to be the logical way to continue their efforts of reducing products' environmental impact and saw the potential of taking their sustainability work to the next level. Furthermore, according to the design director at Electrolux, DfSB could also be a way to differentiate on today's saturated market, where many home appliance producers already focus on sustainability in terms of energy efficiency and low-impact materials. DfSB products would attract the so-called green consumers, but also others since both the environmental impact and the cost of use oftentimes are reduced e.g. when reducing energy



consumption. To make the differentiation more noticeable for consumers, environmentally proactive companies that apply DfSB could take the opportunity to push for eco-labelling that include design considerations for reduced user-related environmental impact.

### Future Recommendations

For companies aiming to reduce the environmental impact of a product it is appropriate to start with reducing the intrinsic losses i.e. make the product itself as efficient as possible. We recommend that the next step is to take measures that reduce user-related losses. As indicated by the case, different levels of user activities influenced by the product could be analysed to find ways to reduce the user-related losses. The first level might be perceived as most relevant but, as seen in the project, other activities could be just as important to target to reduce the user-related environmental impact. Chosen target behaviour/-s should have a high resource saving potential, fit the company's strategy and be in line with user attitudes, capabilities and living conditions.

It can be argued that companies' lack of knowledge and limited implementation of DfSB is a result of the field's recent introduction in both academic research and industry. To enable DfSB work, the expertise within companies needs to be extended and DfSB-thinking must become an inherent part of user research, design and evaluation processes. Hence, we argue that methodologies and techniques that facilitate the implementation of DfSB in companies' current product development processes should be developed.

As seen in the master thesis project, by applying DfSB during the development process, it is possible to develop innovative ideas with pioneering functionality satisfying implicit user need and promoting sustainable behaviour. As this innovativeness can help companies to differentiate on today's saturated market, we think that DfSB could be beneficial not only for environmentally proactive companies but for all companies striving to become market leaders.

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## The PUMA Environmental Profit & Loss Account – Taken to the Next Level

Stefan Siedel

Deputy Head

PUMA S.A.F.E. (Social Accountability and Fundamental Environmental Standards Department)

Germany

### Abstract

In 2011, PUMA established – as the first company ever – an Environmental Profit & Loss Account (E P&L).

### What is this?

While nature is much more to us humans than a mere ‘business,’ the E P&L seeks to answer the seemingly simple question: How much would our planet ask to be paid for the services it provides to PUMA if it was a business? And how much would it charge to clean up the ‘footprint’ through pollution and damage that PUMA leaves behind?

Our operations and supply chain depend on nature for services such as fresh water, clean air, healthy biodiversity and productive land. The PUMA E P&L is the first attempt to measure the immense value of these services to a business, and the true costs of a business’s impacts on nature.

The PUMA E P&L is simply a means of placing a monetary value on the environmental impacts along our entire value chain. Although we pay fees to local authorities for services such as the treatment and supply of water, the true costs of natural resources and our environmental impacts remain externalized and unaccounted for. The E P&L represents how much we would need to pay for the impacts we cause and the services nature provides so that PUMA can produce, market and distribute footwear, apparel and accessories made of leather, cotton, rubber or synthetics for the long run.

Providing goods and services will always have some impact on the environment. The challenge for us is to reduce our impact on the environment (the ‘loss’ in an E P&L) as far as possible while continuing to deliver value to our customers – and looking for ways to return value to the environment.

### Why did we do this?

We have set ourselves targets to reduce CO<sub>2</sub> emissions, energy, waste and water in PUMA offices, stores, warehouses and direct supplier factories by 25 % by 2015 and launched an environmentally friendly product packaging – our Clever Little Bag. While all these initiatives are crucially important to help reduce PUMA’s negative environmental impact, never before had a company integrated and accounted for the true costs of nature’s services, which all businesses depend on. It is a common practice in the corporate world that this ‘inherent’ value of nature is not defined and integrated into a company’s accounting. Corporations believe that businesses solely rely on financials and are driven by their ‘bottom lines.’ But luckily, even those concerned only about bottom-lines and not the fate of nature are beginning to realize that the sustainability of business itself depends on the long-term viability of ecosystems.

A challenge for all companies is to build an increasingly sustainable and resilient business model while also delivering competitive advantage. PUMA aims to be the world’s most desirable and sustainable Sportlifestyle company and the E P&L is one of the principal tools by which we hope to gain the information and insight required to achieve this.

The PUMA E P&L revealed that over half of all environmental impacts are associated with the production of raw materials such as leather, rubber or cotton in PUMA’s supply chain. More than ever

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we have started to identify more sustainable materials to be used for our products in order to reduce the extensive environmental impact occurring at the level of raw material production and processing.

### **The Cradle to Cradle® Concept**

In a long-term cooperation with the Environmental Protection Encouragement Agency (EPEA) PUMA is currently investigating the development of recyclable products according to the Cradle to Cradle® concept. In the Cradle to Cradle® method of production, material flows are formed with conscious consideration of protecting resources. Usually, raw materials are taken and turned into products, are sold and then end up in waste dumps or incineration plants whereby the materials' value is then lost forever.

Rather than attempting to reduce the linear material flows and present-day methods of production, the Cradle to Cradle® design concept envisages their redesign within circular nutrient cycles in which value, once created, remains of worth to both man and nature.

In line with our Sustainability Index (S-Index) standard that serves as a benchmark for sustainable products, our long-term vision is to use innovative and safe materials and design concepts for our products that can be disassembled and recycled as technical nutrients or composted as biological nutrients.

## **SUSTAINABILITY@P&G - About Sustainable Product Design, Driving Sustainable Consumer Behaviour and Winning Through Partnerships**

Dr. Mark Stalmans, PhD  
Manager Scientific External Relations  
Procter & Gamble  
Temselaan 100  
Belgium

### **Overview**

An overview is given of Procter & Gamble's approach to sustainable innovation. P&G is integrating its recently announced long-term sustainability vision and 2020 goals into its operations and brand strategies. All phases of the company activities are covered, including raw material procurement, detergent manufacturing, transport and distribution, sustainable product design, the consumer in-use and post-consumer phases. The most important opportunities for sustainable design of detergents and cleaning products are reviewed as well as the critical role that consumers, brands and brand manufacturers, retailers, influencers, and other stakeholders play in the area of sustainable consumer behaviour. Major challenges can best be addressed by novel ways of collaboration opportunities, such as sharing and reapplying best practices, driving more sustainable cleaning behaviour via multi-stakeholder consumer education and engagement initiatives.

### **P&G and Sustainability**

Sustainability, sustainable development and innovation have become buzzwords with many possible meanings. To the sector of detergent and cleaning products, *sustainable innovation* is not a nebulous phrase. It has become a unifying, inspiring and energizing term for researchers, brand managers and opinion leaders. The term is used frequently by researchers and business managers around the world but it is equally well used when company and industry progress is reviewed with policymakers and NGOs.

P&G's definition of sustainable development is about improving the quality of life for everyone, both in the developed and developing worlds. This aligns with P&G's Company Statement of Purpose: "*We will provide branded products and services of superior quality and value that improve the lives of the world's consumers, now and for generations to come*". P&G will remain committed to improving consumers' lives through its brands and by contributing to the sustainability of the planet.

This opportunity to touch and improve lives comes with a responsibility to do so in away that preserves the planet and improves the communities in which P&G operates. P&G is making strong progress in the focus areas of Products, Operations and Social Responsibility, enabled by its employees and stakeholders.

In 2010, P&G announced a new long-term environmental sustainability vision and a series of 2020 goals, focused on Products and Operations. Since then, P&G is integrating this new vision into each business unit and across P&G's operations, and significant progress has been reported towards the new goals. For more information, see [www.pg.com/sr](http://www.pg.com/sr).

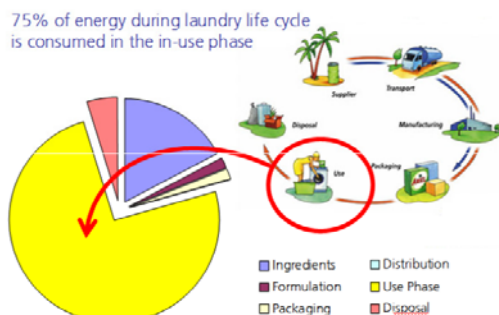
## Sustainable Innovation 12



Figure 1: Procter & Gamble 2020 Sustainability Goals (www.pg.com)

In the environmental area, P&G recognizes both its responsibility and the opportunities available from improving the sustainability profile of its products and operations. Procter & Gamble has been a leader in environmental responsibility for over 50 years. At each point along the road to sustainability, P&G has been one of the first to act, whether it was in designing processes or methods for monitoring and assessing environmental impacts, innovating products to have a better eco-efficiency, or using its global scale to be a significant driver and catalyst for broad scale deployment of safe and sustainable products and operations. P&G's life-cycle-based thinking and scientific research have historically supported the most sustainable product design.

## The Use Phase Dominates



Source: www.scienceinthebox.com

Figure 2: Lifecycle Analysis: Consumer Use phase dominates energy use

Life cycle analyses have been conducted to assess the material, energy and water requirements and environmental emissions across all life cycle phases, including raw material acquisition and transport, product manufacturing, packaging and distribution, consumer use and post-consumer disposal. With detergents for example, around 70-80% of the total lifecycle energy is consumed in the consumer use phase, mostly to heat the water in the washing machine (Figure 2). Consequently, the most substantial energy savings can be achieved when the consumer uses the detergents. As society has begun to concentrate on wider sustainability issues (e.g. ecological footprint), P&G's Fabric and Home Care business unit has been proactively directing its research capacity to product formulations that can also address such overarching societal concerns as energy use, climate change and water conservation.

### Sustainable Product Innovation In P&G'S Fabric and Home Care Business

The environmental sustainable innovation programmes in P&G's Fabric and Home Care business unit are built around a set of core themes *where the greatest impact to the company's overall sustainability strategy can be made for detergents and cleaning products*: efficient use of energy; efficient use of water; sustainable packaging; product compaction; and driving a more sustainable consumer behaviour.

- **Efficient use of energy and energy savings:** As the use of washing machines and dishwashers make up a considerable percentage of household energy consumption (and greenhouse gas emissions), especially in heating the water (Figure 2), P&G have concentrated on means to formulate products to wash effectively at cooler temperatures. Ariel's Coolclean technology (laundry) and Fairy's Active Burst formulations (automatic dishwashing) have been successful in strong outstanding performance at low temperatures, saving the consumer money on electricity bills while reducing CO<sub>2</sub> emissions on a large scale and without compromising cleaning performance or convenience.
- **Efficient use of water and water savings:** P&G's strong history of research in water issues has helped it to develop products that clean well while saving water. They have collaborated actively with other stakeholders to persuade consumers to use fuller loads, choose energy and water saving cycles and avoid pre-washing.
- **Product compaction and concentration:** Compacting detergents and fabric softeners provides significant environmental benefits: the reduction of materials means less packaging, less processing aids and less energy used in the production, packing and transportation phases. Since the 1980s, P&G has been systematically compacting its products and educating the consumer on the lower dosing requirements and the environmental advantages to choosing compacted products.
- **Sustainable packaging:** Packaging production and use consumes material resources, energy and space and requires post-use waste management processes. P&G has focused much of its research to improving the sustainability profile of its packaging and reducing packaging weight. For example, researchers have introduced a material optimisation procedure for the design of Ariel bottles that uses plastic in lower quantities but optimally tailored to meet stress requirements. Wherever possible and economical, P&G is using recyclable and recycled materials in plastic bottles and cardboard packaging and is actively collaborating with broader coalitions how to use more renewable materials, such as in the recently announced collaborative programme around plant-based PET packaging technologies (Coca-Cola Company, Ford, Heinz, Nike, P&G). Continued product compaction also contributes significantly to the reduced use of packaging materials.
- **Driving more sustainable consumer behaviour:** None of the achievements from P&G's sustainable innovation strategy would succeed if consumers will not show a preference towards more sustainably designed detergents and adapt their wash practices.

### Driving Sustainable Consumer Habits

P&G with a range of stakeholders, influencers and celebrities have developed incentives and extensive campaigns to encourage consumers to change their wash behaviour. A 2002-2007 IPSOS research survey indicated that the Ariel Turn-to-30° campaign had made a considerable impact in lowering the temperature UK households washed at.

2002 – **2% of all loads washed at 30°**  
 2005 – 1<sup>st</sup> CoolClean campaign  
 2006 – 2<sup>nd</sup> CoolClean - Turn To 30°  
 2007 – 3<sup>rd</sup> CoolClean - Do A Good Turn  
 2007 – **17% of all loads washed at 30°**

Figure 3: Effect of Ariel Coolclean campaigns on consumer behaviour - washing at 30°C (UK 2002-2007)

Driving consumers to adopt more sustainable wash practices is not simply something a typical marketing campaign can achieve. So many other factors come into play: innovative product design, assurance of continued cleaning performance, attractive message communicated locally, clear translation of the benefits, collaboration with and engagement of a wide array of stakeholders to multiply the message, as well as the public recognition of brand leadership in the field of sustainability. With these elements, P&G and its partners has achieved a certain degree of success in persuading consumers to wash more sustainably.

With the next generation of sustainable innovations introduced in laundry and cleaning brands, the consumer will be even more attracted to the triple message of performance, price and planet.

**Winning Through Partnerships and Novel Collaboration Models**

Novel collaboration models emerge in several areas, complementing the more conventional strategies. Some of the biggest challenges such as the development and broad commercialisation of sustainably sourced renewable materials or conversion of consumer habits into more sustainable practices cannot be addressed by individual organisations but will only be successfully achieved by broad partnerships and collaborative alliances.

One of P&G’s recent sustainable operational innovations is the redesign of the transportation capability to deliver fewer and environmentally friendlier miles reducing CO<sub>2</sub> emissions. In the area of intermodal freight transport, P&G aims to increase the use of rail and inter-modal transportation of its manufactured goods in Europe from 10% (2010 baseline) to 30% by 2015. Since the start of the programme, CO<sub>2</sub> emissions from transport have been reduced with more than 45,000 tons (2010-2012) and the equivalent of more than 70,000 truck trips (2010-2012) have been saved without a trade-off on cost and service. The model encourages non-competing companies to join the intermodal transport programme so that collectively a higher efficiency and more environmental savings can be achieved than could be achieved by the individual companies.



Figure 4: P&G rail and inter-modal transportation programme



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In 2007, a group of P&G waste experts started the GARP project (Global Asset Recovery Purchases) to enable waste-to-worth revalorization of manufacturing waste. This aimed to help manufacturing sites optimize their waste management systems by maximizing recycling tonnages and revenue and minimizing disposal tonnages and costs. Partnerships with selected waste management 'Site Solution Providers' leveraged economies of scale and industry expertise and minimized complexity. Alternative use was a new approach applied to reuse scrap product or other wastes as raw materials by 3<sup>rd</sup> party manufacturers. The goal was to have all sites send near zero waste to landfill by 2020. In their first year, four sites achieved the target of zero waste to landfill. By 2011, sixteen P&G sites achieved zero waste to landfill. For example, pulp and waste from diaper production process has been re-used in the manufacture of industrial spill control pads because of their absorbent qualities. Waste from production of laundry powders and liquids are blended into products for industrial cleaning, while residues from hard surface cleaners and hand dish washing liquid are blended into car/truck wash products. In all cases, strict HS&E and QA guidelines are respected to ensure the safety and quality of the re-used products.

Novel collaborations are not limited to products and operations. In the area of washing at lower temperatures, P&G increasingly manages to find the right approach with the consumer, successfully driving a more sustainable wash behaviour with no compromise in the consumer's expectation of a superior wash performance or convenience. Especially the mutually beneficial collaborations with outside stakeholders and consumer influencers has helped to convey the message of a collective responsibility for more sustainable behaviour, and specifically how the actions of many individuals and small behavioural changes can contribute to a substantially improved sustainability profile of washing and cleaning.

This approach reinforces the consumers' satisfaction, strengthening brand loyalty and trust in using more sustainable products, marrying the needs of consumers in western societies with the need to develop more sustainable lifestyles.

### **Said Simply: Innovate, Collaborate, Educate**

This review shows how sustainability thinking and lifecycle principles are integrated into all phases and activities of the cleaning products sector value chain, starting from raw material sourcing, product manufacturing, transport and distribution, consumer and customer use, as well as recovery, re-use and recycling in the post-consumption phase. While ample work needs to be done to address the significant challenges ahead, it is equally clear that innovative and effective sustainability strategies are becoming mainstream in this relatively mature sector.

3 relatively simple ideas - ***Innovation, Collaboration, and Education*** - will positively shape our future.

Innovation will be key to fundamentally address the sustainability challenges. Product and technological innovations will provide superior products that are designed to enable consumers to conserve resources. A range of novel collaboration models will be needed since no individual company has the innovation capacity to solve all issues. Importantly, consumers need to be engaged to adopt more sustainable habits, such as correct detergent dosing and washing at lower temperatures. Conventional communication programmes and regulations will fall short, while consumer education and engagement towards a more sustainable behavior can only be achieved by broad, multi-stakeholder initiatives.

When these 3 ideas are fostered, they will drive brands, the economy and the planet towards a more sustainable future.

There is a long way to go on the journey to become an ever-increasing sustainable company. 2012 marks the 175th year P&G has been in business. Looking toward the next 175 years and more, P&G is designing sustainability even more deeply into the way it does business: through its purpose, products and operations, as well as its business and stakeholder relationships with the aim to improve the lives of the world's consumers within the constraints of a "one planet" footprint.

For further information on Procter & Gamble and the sustainability programmes for detergents and cleaning products, visit [www.pg.com](http://www.pg.com) and [www.scienceinthebox.com](http://www.scienceinthebox.com).

## Is E-Media More Sustainable Than Print?

Michael Sturges  
Senior Researcher  
Innventia Edge (Innventia UK Ltd)  
Head office: Box 5604,  
SE-114 86 Stockholm  
Sweden

Malin Kronqvist  
Project Manager – Sustainable Solutions  
Innventia AB  
Box 5604, SE-114 86 Stockholm  
Sweden

Anita Teleman  
Research Manager – Printing Solutions  
Innventia AB  
Box 5604, SE-114 86 Stockholm  
Sweden

Cathrine Löfgren  
Project Manager – Sustainable Solutions  
Innventia AB  
Box 5604, SE-114 86 Stockholm  
Sweden

### Background

The Roadmap to a Resource Efficient Europe (European Commission 2011) highlighted the need for accelerated innovation in materials, products, services and technologies as key to enabling smart, sustainable growth. However, this must be accompanied by a firm understanding of the environmental, social and economic implications of emerging and disruptive technologies.

The publishing industry provides an excellent case in study. Changing lifestyles, behavioural changes and emerging technologies are driving radical changes to the way newspapers, magazines and books are consumed. Traditional physical publishing supply chains are being replaced and/or supplemented by digital media. The initial move to online publishing focused on the delivery of standard content delivered over the Internet and accessed via consumers' PCs and laptops. More recent and current developments are seeing the rapid emergence of publications using the platforms provided by tablets, smart phones and, in the case of books, dedicated e-readers.

Physical newspaper, magazine and book publishing is built on energy intensive processes such as pulp & papermaking, printing and physical distribution. In some publishing supply chains difficulties in forecasting demand result in high levels of unsolds, which are then repulped without ever having been consumed. Thus, there is an immediate presumption that the services provided via these new e-channels offer a more sustainable alternative compared to traditional publishing. At first sight, they

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appear to offer significant opportunities for dematerialisation, waste reduction, energy efficiency and carbon reduction.

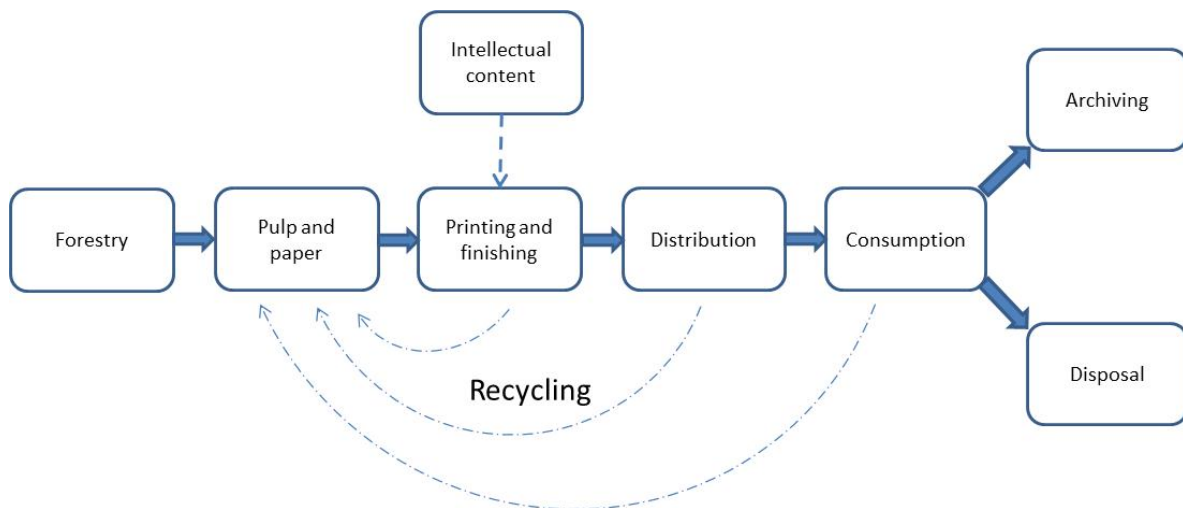
However, these presumptions have so far been supported by very little hard data or structured analysis. Tools and methodologies are available for understanding the life cycle implications of products and services, but the pace of change in technologies and consumption patterns means that these have only been applied to the emerging digital publishing sector on a limited scale. Technology providers themselves seem more focused on product functionality and impact of their own devices in isolation, rather than taking into account the wider life cycle impacts.

This paper presents an overview of conclusions drawn from a review of the existing literature plus the results of original research and analysis by Innventia in this field. The aim of the paper is to provide insights into the potential environmental impacts of traditional printed media compared to digital media platforms, clearly identifying where there are knowledge gaps and uncertainties that need to be considered. The subsequent implications for stakeholders in the publishing supply chain are discussed, and comments on implications for other sectors are provided.

### Overview of the product life cycles

The product life cycle for traditional publishing (Figure 1) is well known.

Figure 1: Generic product life cycle for traditional printed publications

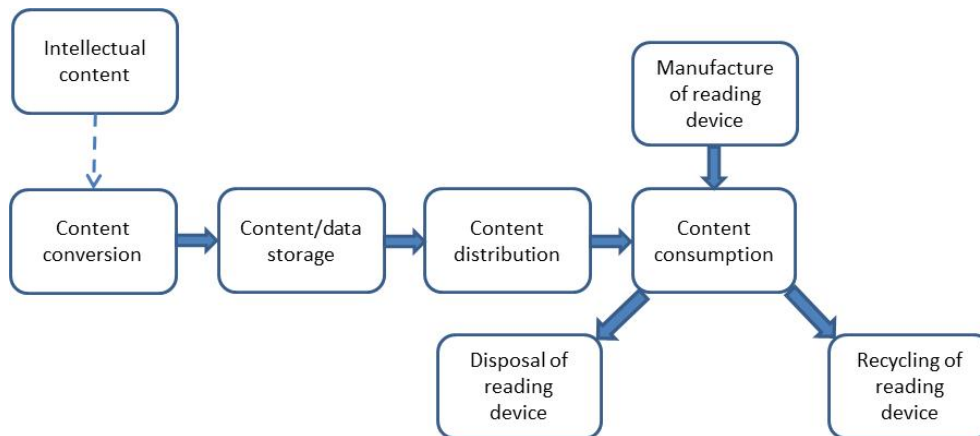


Key environmental considerations in the life cycle of printed publications include:

- Sustainable forest practices and
- Forest carbon sequestration and carbon stored in products
- Energy consumption, emissions, effluent and sludge associated with pulp and paper making
- Energy consumption, emissions, effluent and solid wastes associated with printing and finishing processes
- Process (paper) waste from printing and finishing processes (e.g. set-up and running wastes, trimmings, etc)
- Transport emissions throughout the supply chain, but particularly associated with product distribution
- Unsolds or returns arising through oversupply, which are almost exclusively repulped
- End-of-life scenarios for used printed matter – recycled materials re-enter the paper cycle; fibres in products disposed of by incineration or landfill are lost to the system

The product life cycle for digital publishing (Figure 2) is less readily recognised.

Figure 2: Generic product life cycle for digital publishing



Within the life cycle, content conversion is the process of converting the materials supplied by the publisher into the appropriate electronic formats. This will be a desk-based activity. The main source of environmental impacts from this stage of the supply chain is likely to be emissions arising from the electricity consumed to power hardware. Impacts associated with the production of hardware and emissions arising from the subsequent waste management of obsolete equipment may also be significant.

There is plenty of publicity regarding the high energy demands of data centres. Energy is required to power servers and hardware and to deliver air conditioning/cooling and to maintain an uninterruptable power supply (UPS). A key metric is the power usage effectiveness (PUE) which considers the total site energy requirements (e.g. including energy required for air conditioning, UPS, and other overheads) compared to the energy used for powering the servers and mainframes. The PUE of legacy data centres can be as high as 5.0, whereas new designs can achieve a PUE as low as 1.2-1.3 (Tamburini & Goodman 2009). Impacts associated with the production and subsequent waste management of data centre hardware should also not be overlooked.

Publishers have little direct influence over the distribution network, but it is still an integral part of the digital publishing supply chain. Depending on the format and end-user, content may be distributed over the Internet or over a wireless network. The main sources of impacts from content distribution are likely to be:

- Emissions arising from the electricity consumed to power the networks, etc
- Emissions arising from the production, maintenance and subsequent waste management of network infrastructure and hardware

Consumption of digital content requires a reading device. A key source of the environmental impact to consider will be the emissions associated with powering the device. The reading device may be a dedicated reading device or it may be a device which has many uses (such as a laptop) in which case the impacts associated with production and subsequent waste management of devices needs to be allocated across the many functions it delivers.

For both systems, the production of the intellectual content is often overlooked when the environmental impacts are calculated. However, this can make a significant contribution to the overall impacts. For example, transport related impacts arising from journalism, photo shoots, etc.

### Existing literature

The environmental credentials of digital media compared to conventional physical publications is the subject of vociferous debate. Much of this debate is poorly informed, subjective and sometimes deliberately provocative or biased. Limited structured and/or peer reviewed analysis has been published. Unfortunately, some studies lack rigour and transparency but have achieved influence. Where relevant, credible publications have been identified and reviewed it is apparent that:

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- Modelling and data decisions can have a significant influence on the results achieved and conclusions drawn
- Some studies suggest that the impacts associated with the production of reading devices may make a significant contribution to the overall impacts of the digital publishing life cycle
- However, there is only limited data available on the environmental impact associated with the production and disposal of reading devices, and where data is available this lacks transparency
- Data centres are energy intensive operations when considered in isolation, but once this is allocated across the many tasks performed by the data centre the contribution to the overall impacts of an individual digital publication may not be significant
- The environmental impacts of the supporting distribution network (for example, the Internet or wireless networks) are poorly understood but should not be overlooked
- Product substitution ratios are important – for example, one e-book does not necessarily directly displace one printed book.

Despite being dated in terms of technology considered, a key reference in this field is screening life cycle assessment which aimed to describe the potential environmental impacts of distributing newspapers by three different channels: traditional printed newspapers; an online (web-based) newspaper; and a tablet e-reader using e-paper technology (iRex Illiad) (Moberg et al 2007). A secondary aim was to identify data gaps and areas where more information is needed.

The results showed that, depending on the assumptions made and systems considered, the three delivery channels were potentially comparable in terms of global warming potential. Key aspects which affect the results include:

- Number of readers per copy assumed for the printed and e-reader newspapers
- Reading time for the web-based newspaper
- The lifetime considered for the electronic devices
- Multi-use implications for the electronic devices
- Location assumed and subsequent energy mix for energy intensive processes such as papermaking, Internet access, e-reader charging, etc.

Another valuable study in the literature is Gough (2008) who concludes that end-user behaviour is critical in defining the overall impact of the electronic delivery of scientific journals but, as yet, very limited data exists on this aspect of publishing. Borggren & Moberg (2009) studied the potential impact on the environment from paper books and e-books. They also conclude that user behaviour is an important aspect in defining the environmental impact of the two systems. Enroth (2009) found that the global warming impact of a web-based teaching aid is approximately ten times greater than that of a printed text book, as the text book is used by so many users over a long period of time.

Several studies and publications reviewed focus on the comparative impacts of e-books and traditional books, for example Kozak (2003), Ritch 2009, Green Press Initiative (2011) and Shimizu (2011). Results achieved and conclusions presented are not consistent across the studies, highlighting the importance of data and knowledge gaps, the influence of baseline assumptions and the need for transparency.

### **The case of magazine publishing in Sweden**

This study, conducted by Innventia (Kronqvist et al 2010), aimed to describe the potential environmental impact of a printed magazine and its comparable online content. Both the physical and online materials are produced and consumed in Sweden.

The study included all life cycle stages, from cradle-to-grave. The main impact categories considered in the study are abiotic resource depletion, acidification potential, eutrophication potential, global warming potential (100 years), ozone depletion potential and photochemical ozone formation potential. Models were compiled using a specialist LCA tool. The models were based on a combination of primary data and best available secondary data. No external critical review took place. The study was supported by Sveriges Tidskrifter (SMPA – Swedish Magazine Publishers Association), Posten Meddenlande (Swedish Postal service), Pressretur (a Swedish producer responsibility organisation), SCA (international paper manufacturer) and RISE (Research Institutes of Sweden).

**Functional unit**

The printed magazine and the online content considered in the study were delivered by the same publisher, covering the same topics and carrying the same branding. However, the specific content within the two formats is not the same and consumption patterns for magazines and online content are different. Magazine reading tends to be a relaxation experience while online content is often consumed in short bursts and may be in the form of an information searching experience.

Nonetheless, for the purposes of the study, the two formats are considered to compete for an individual reader’s time, and this is reflected in the functional unit which was set at “the consumption of a magazine or equivalent online content for one year by one reader”

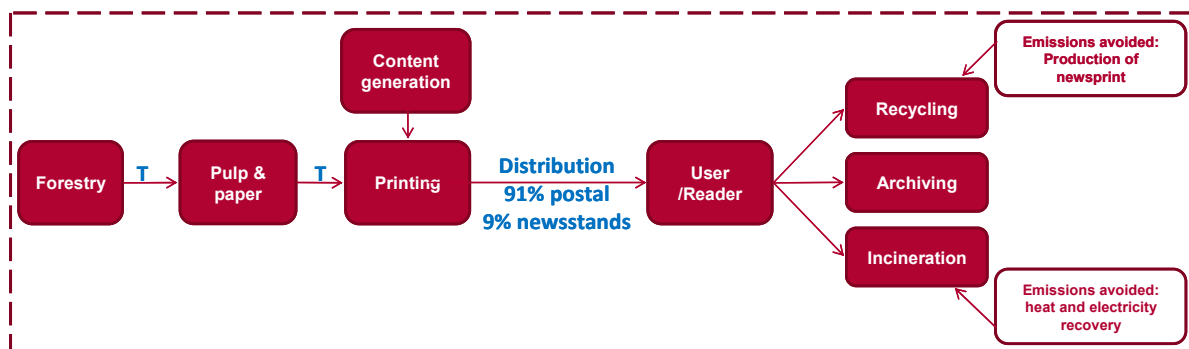
**Characteristics of the paper magazine system**

The magazine considered in the study is produced and consumed in Sweden. The system boundary encompassed all life cycle stages from wood harvesting through to end-of-life. System expansion accounts for avoided emissions associated with incineration (energy recovery) and recycling. Data concerning number of readers per copy, reading time per copy and distribution regime were taken from a study on the behaviour of magazine readers in Sweden conducted by Sveriges Tidskrifter.

Table 1: Key parameters considered for the printed magazine system

Parameter	Printed magazine
Edition	12 issues (with nos 2 and 3 combined as one)
Size	Total 1,324 pages, including cover (approx. 120 pages per issue)
Format	21.7 cm x 28 cm
Basis weight of paper - body	65 g
Paper - body	GraphoCote, LWC paper
Basis weight of paper -cover	150 g
Paper - cover	Tom&Otto (LCI data for GraphoCote used)
Printing	Heatset web offset (HSWO) 4-colour printed in Sweden
Parameter	Behaviour of a reader of paper magazines
Number of readers	3.23 readers per copy
Time taken in reading	40 minutes
Distribution	91% of magazines supplied through the postal system and 9% through newsstands

Figure 3: System boundary and flow chart for baseline scenario for paper magazine



**Characteristics of the online content system**

Just as every magazine is different, every website is different. Describing the production and use of an average website or online publication to determine the typical impact of online publishing is difficult, since the following parameters will vary and may consequently affect the results achieved and conclusions drawn:

- Number of pages and type of content

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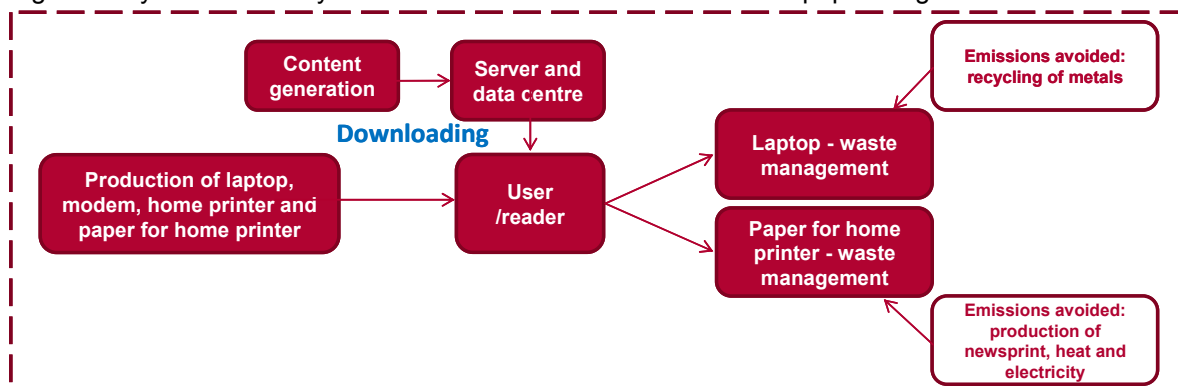
- Number of readers, i.e. the number of users amongst whom the impact of producing and hosting the website are divided
- Reading time and the number of visits made by the reader
- Equipment used by the reader
- Home printing – does the user print out any materials and if so what types of printing and paper are used?

Nonetheless, a baseline scenario was described and parameters were varied to provide some indication of the sensitivity of results. The model consists of the following stages: production of hardware, data centre (hosting), downloading (i.e. use of the Internet infrastructure to retrieve the materials), use (online reading and printing at home), waste management and avoided emissions

Table 2: Key parameters considered for the printed magazine system

Parameter	Web magazine
Edition	7 days /week
Servers at data centre	500 W
Time taken in reading	40 minutes/month, divided among 3 visits to the site per month
Online reading hardware	Laptop computer, ADSL-Modem
Profile for home laptop and ADSL-Modem use	For a 24 hour period, laptop is in active/on mode for 5.52 hours; on standby for 1.92 hours; off for 16.56 hours. Impacts associated with standby and off modes are allocated to the active mode. Modem was assumed to be on for 24 hours per day.
Geographical location for reading	Online reading in Sweden, using the Swedish electricity supply
Print-outs	2 single-side print-outs per month

Figure 4: System boundary and flow chart for baseline scenario for paper magazine

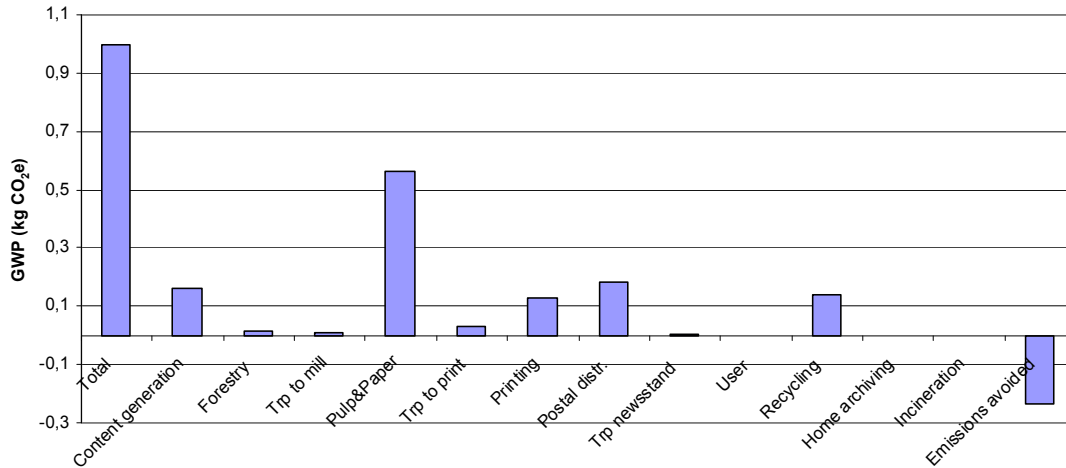


### Results – printed magazine

For the printed magazine system the results were as anticipated, following the trends from previous studies. The results are fairly consistent across the impact categories with pulp and paper being the main contributor, followed by printing or distribution. See Figure 5 for the global warming potential (GWP) results and Figure 10 for other impact categories. Sensitivity analysis (Figure 6) shows that the assumption regarding the number of readers per copy has significant influence on the results.

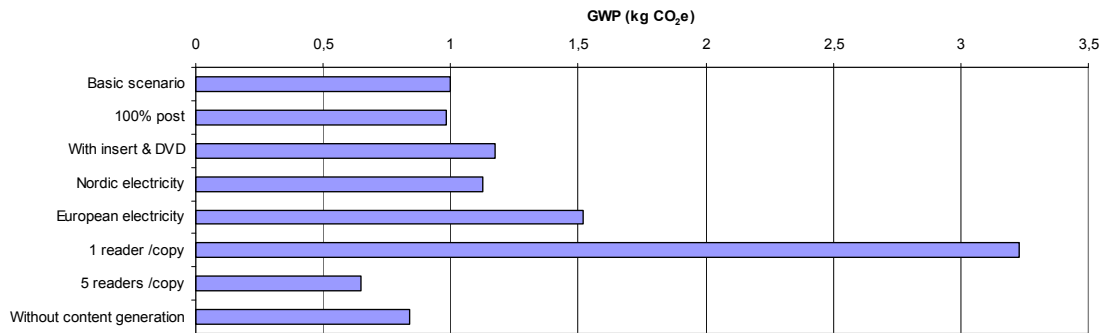
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Figure 5: Global warming potential results – baseline scenario, printed magazine, for one reader and one year



(Basic scenario for a printed magazine. The Global Warming Potential (GWP) for one reader per year. Results are per life cycle stage. The total result is the sum of emissions. The CML2001 – Dec 07 method was modified to no biogenic CO<sub>2</sub> emissions)

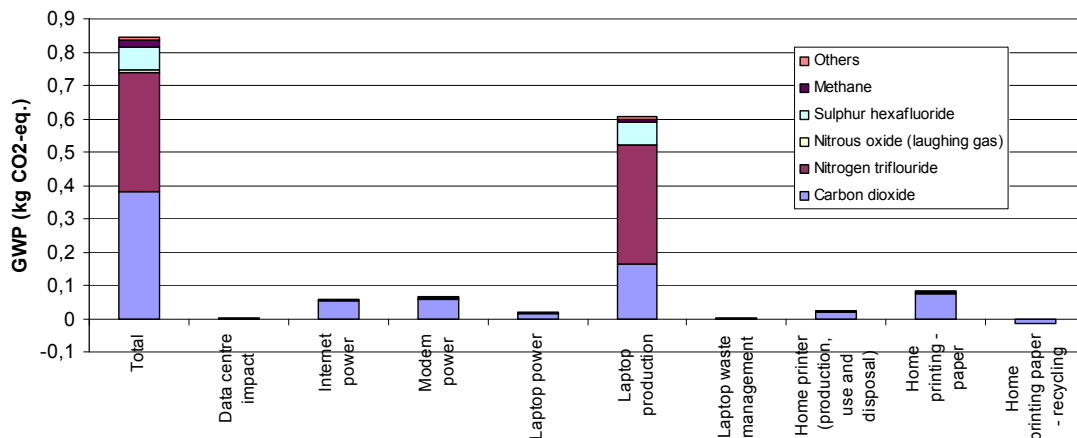
Figure 6: Sensitivity analysis for printed magazine



## Results – online content

The researchers were initially surprised by the GWP results for the online publishing scenario (Figure 7). Impacts associated with the production of the laptop used for reading dominate, accounting for approximately 70% of the total GWP results. This is despite the fact that the impacts associated with production of the laptop have been allocated across all of its uses assuming a four year life time.

Figure 7: Global warming potential results – baseline scenario, online content, for one reader and one year



(Basic scenario for online publishing. Global Warming Potential (GWP) for one reader per year. Results per life cycle stage. The total result is the sum of emissions. The CML2001 – Dec 07 method was modified to no biogenic CO<sub>2</sub> emissions)



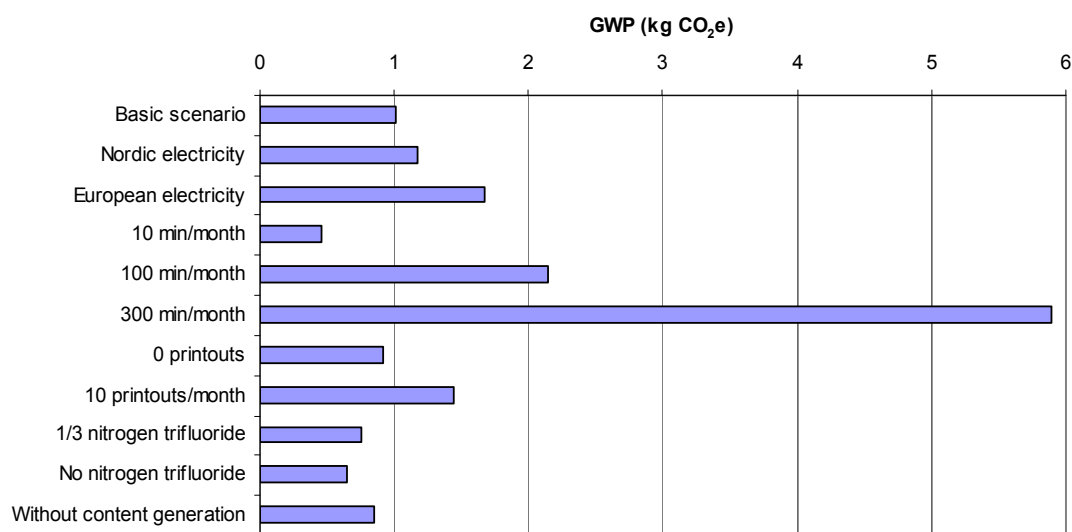
Emissions of nitrogen trifluoride (NF<sub>3</sub>) account for around two thirds of the laptop production impact. A detailed analysis of the laptop production background data showed that these emissions occur during the assembly of the LCD screen. NF<sub>3</sub> is a chemical used for flushing the production chambers in high volume production of LCDs, silicon-based thin film solar cells and similar equipment. Although gas recovery systems operate, some NF<sub>3</sub> escapes to atmosphere. NF<sub>3</sub> has a 100 year GWP of 17,200, and therefore only small emissions can lead to very high GWP results.

Best available data for the manufacture of electronic components was derived from Ecoinvent. However, this data reflects technology and operations from 2001. The use of NF<sub>3</sub> is being replaced with elemental fluorine in state-of-the-art high volume production of flat panel displays and solar cells, but suppliers were not able to estimate the market penetration of this reduced impact technology. Therefore, the NF<sub>3</sub> emissions reported will be an overestimation and have been subjected to sensitivity analysis.

Even excluding NF<sub>3</sub> emissions from the results, the production of the laptop used for reading still makes the most significant contribution to the overall GWP results. This reflects the high energy demand for producing some components and the fact that many components are manufactured in countries with a carbon-intensive national electricity mix.

The sensitivity analysis (Figure 8) reveals that the location of the reader accessing the content, and therefore the carbon intensity of the electricity used to power or charge the laptop, is an influencing factor. However, the assumed reading time has the most significant influence over the results achieved.

Figure 8: Sensitivity analysis for online content

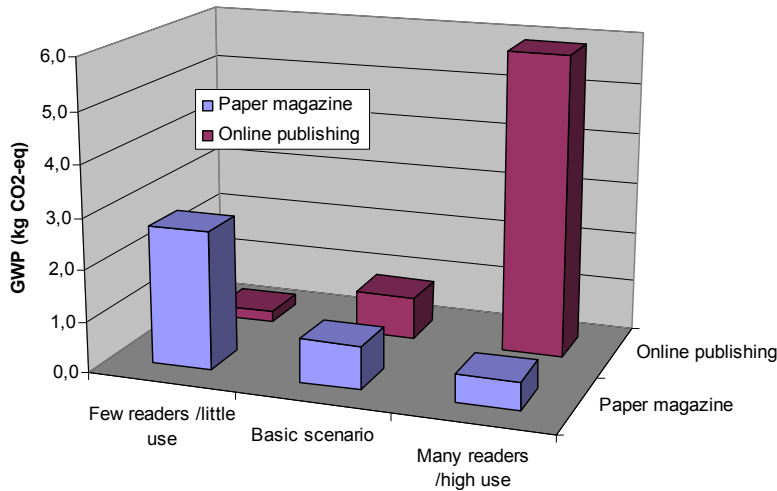


**Comparison of the printed magazine and online content**

Figure 9 shows how the GWP results vary for the systems according to user behaviour. With little use/few readers, the reading of material in a paper format has a greater impact. With greater use/many readers, the reading of online materials has a greater impact.

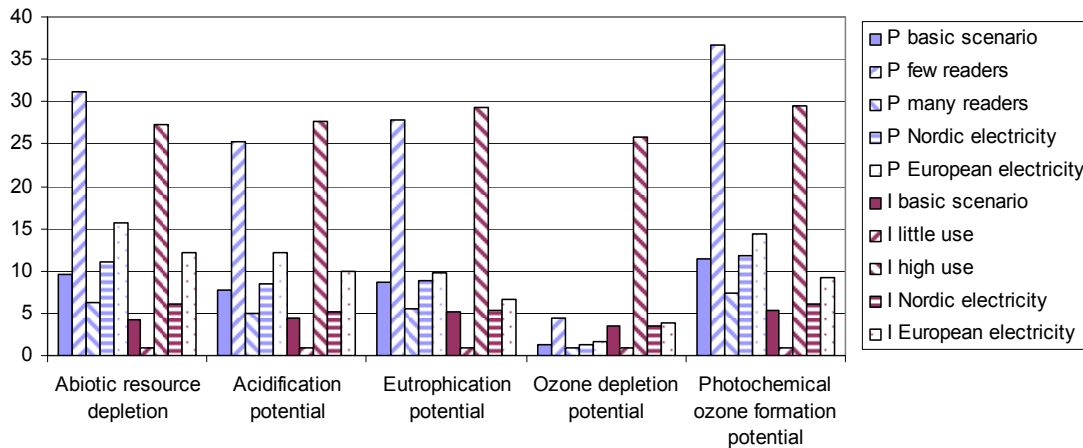
For the other impact categories considered the comparison between reading the printed magazine or online content is shown in Figure 10. For abiotic resource depletion, acidification potential, eutrophication potential and photochemical ozone formation there is a tendency towards a greater impact for reading materials in paper format than for online reading. For ozone depletion potential the reverse is true.

Figure 9: Comparative GWP results



(Global Warming Potential (GWP) for one reader per year, based on different assumptions and choices. Paper magazine: few readers = 1 reader/copy; Basic scenario = 3.23 readers/copy; many readers = 5 readers/copy. Online publishing: little use = 12 min/month and no print-outs; Basic scenario = 40 min/month and 2 print-outs/month; high use = 300 min/month and 10 print-outs/month. The CLM2001 – Dec 07 method was modified to no biogenic CO<sub>2</sub> emissions)

Figure 10: Comparison of different impact categories



(Comparison of different impact categories for one reader per year, based on different assumptions and choices. Relative unit: for each impact category, the variation with the lowest value was numbered 1 and the other variations have been compared to this. P = Paper magazine; few readers = 1 reader/copy, Basic scenario = 3.23 readers/copy, many readers = 5 readers/copy. O = Online publishing: little use = 12 min/month and no print-outs, Basic scenario = 40 min/month and 2 print-outs/month, high use = 300 min/month and 10 print-outs/month.)

### Implications for stakeholders in the publishing supply chain

Understanding consumer behaviour, predicting how technologies will be used, and identifying the potential impacts at an early stage are essential elements for achieving the transition to more sustainable products and services. The research into e-publishing demonstrates both the opportunities and challenges faced when rapidly bringing new technologies to the market place.

#### The relationship between print and digital media

Firstly, it should be explicitly acknowledged that digital media channels do not necessarily directly displace print. Digital offerings are often complimentary to the existing printed brands. This is particularly true in the consumer magazine publishing industry, where magazine websites have been used as vehicles to promote the printed editions. Publishers will continue to use both print media and digital media to deliver their products.

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Having said this, the relative importance of digital media in the product mix is increasing fast. In some sectors (e.g., trade magazines), it is true that online content has completely replaced some print titles. The recent and rapid emergence of tablets and smartphones has also made digital and printed media more directly comparable. Publishers are beginning to issue magazines App completely identical to the printed editions. This trend is already apparent in book publishing although evidence suggests that there is not a direct 1:1 displacement ratio between the two formats.

### Keeping pace with change

A key challenge facing publishers who wish to understand and manage their impacts is the rate of technological change and innovation. The Innventia research presented here, which focused on content published on a website and accessed by the consumer using a laptop, is a point in case:.

- Already this scenario looks dated from a magazine publishing standpoint. Whilst advertising revenues and paywalls have delivered limited revenue for webpage based content, rapid growth in tablet and smartphone ownership is providing publishers with an option for amortising content through the provision of App versions of their magazines.
- Current efforts to extend the research to include tablet, smartphone and e-reader accessed content are hindered by the lack of available data on the environmental impacts of these devices or even on the make-up of the devices themselves. This is understandable, given the pace of developments and the need for device manufacturers to guard closely the Intellectual Property within their products.

### Losing control of the impacts does not mean abdicating responsibility

The source of impacts within the supply chain is shifting to stages in the life cycle which publishers do not directly control or influence. In traditional publishing supply chains publishers could make decisions about which papers and printers they used and how many copies would be produced. These decisions would directly influence the scale of environmental impact, and therefore publishers could feel in control.

In contrast, the impacts associated with digital publishing may be dominated by life cycle stages over which they have little or no control:

- User behaviour – what devices they use, how often they replace them, where they are located, whether they print materials out, etc
- Distribution system impacts – arising from the Internet core and edge networks or mobile telecommunications networks
- Data centre management – data management and storage is commonly outsourced.

However, this does not mean that the publisher should abdicate responsibility for these impacts. A recent UK initiative (Two Tomorrows 2012) has brought together publishers to identify how they can influence these elements. For example, choices on whether to deliver streamed or downloadable content; data storage and backed-up strategies; and how long before material is treated as obsolete.

Ultimately, understanding and predicting how users interact with content may be key to reducing the overall environmental impacts of digital media channels.

### So, is e-media more sustainable than print?

The available literature (although sparse) and the analysis undertaken by Innventia challenges the widespread assumption that digital publishing offers a more environmentally sustainable solution than traditional printed publishing supply chains:

- In many cases, the two formats are complimentary rather than competitive. In this respect, the growth of digital media has merely increased the environmental impact of publishing.
- To a large extent, the footprint of digital media and printed media depends on user behaviour. The way materials are consumed will dictate whether a printed or digital publication will be the more sustainable offering.

Without the application of life cycle techniques, impacts in the digital supply chain are often hidden to both the publisher and the reader. This does not mean that the impacts do not exist or that the

published has no responsibility or influence. If the potential sustainability benefits of ICT are to be realised then this is an important lesson for other industry sectors as they move to new e-commerce based models. Further structured, independent and peer reviewed analysis of all e-commerce solutions is required.

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## New Business Models for Sustainable Solutions

Ursula Tischner

Director

Econcept

Cologne

Germany

### Abstract

#### 1. Introduction: From Products to Solutions

Selling products used to be the standard way of doing business. A company makes a product, sells it to a user, receives a compensation, and it is up to the user to finance its purchase, learn how to use it, arrange maintenance for it, insure it if needed, buy any consumables and auxiliary materials the product needs to be operational, discard it after its useful life time, and apply the product for a useful purpose. In the last decades it became more and more clear from theory and practice that this model of selling products is old-fashioned business. Companies should switch their focus on selling need fulfilment, satisfaction, or experiences because that is what clients want and need and what gives companies competitive advantage, enhance added value of their offering, and improve their innovation potential (cf. e.g. Pine and Gilmore 1999, Wise and Baumgartner 1999, Davies et al. 2003, LaSalle and Britton 2003).

From a very different starting point the Sustainability Community comes to the same conclusion: The combined stress (water, air soil pollution, resource consumption, climate change etc.) put on the natural environment today and more so by a growing world population (from 6 billion to 9 billion people in 2050), requires a change in production and consumption systems, resource use and emissions to guarantee survival of humanity on a planet with limited resources and space. Ways have to be found to de-link economic growth (where it is needed due to a growing population) and prosperity from environmental pressure: 'doubling wealth, halving resource use' (von Weizsäcker et al. 1997). This means to start with the needs of consumers and society and to search for ways to fulfil these needs with the best solutions that have the least negative – or even positive – effects on the natural and social environment. This also means to think in production and consumption systems rather than products, because a system design normally can lead to much more radical and innovative solutions than (re) designing a product. We should take final consumer needs – rather than the product fulfilling the need – as a starting point, the degrees of freedom to design need fulfilment systems with considerable sustainability improvements are much higher. Thus, meanwhile Sustainability Designers deal with Product-Service-Systems (PSS, cf. Tukker and Tischner 2006) or Sustainable-Consumption-Production Systems (SCP, cf. the series of books by the European SCORE project, e.g. Tischner et al 2010) to invent radically more efficient, effective and social/fair solutions to fulfil the needs of the present generations without compromising the possibilities of future generations to fulfil their needs (in the true sense of the Sustainable Development definition (WCED 1987).

#### 2. The Goal: System Improvements towards Sustainability

The idea behind these new product-service-systems and hence new business strategies is that need-focused solutions could be inherently more sustainable and more attractive than selling products. Product-services would offer the value of use or a result instead of the product itself, like a "clean clothes-service" versus a washing machine, or a "mobility-service" rather than a car. In these use- or result-oriented services companies offering the service have strong incentives to improve the system's resource and energy efficiency, as they get paid for a defined result/function and try to deliver it in the

most cost effective way. Such a company would probably use an efficient washing machine, or a light and economical car. At the same time consumers likely alter their behaviour as soon as they gain insights in all the costs involved with the use. For each kilometre in a car from a car-sharing company, one would pay the actual costs. With an own car, this is much more difficult, as the purchasing costs, taxes and fuel costs all add to the total costs. Several studies and publications support these assumptions such as Stahel, 1998; Meijkamp, 2000; Charter and Tischner, 2001; Mont, 2004; Tukker and Tischner 2006). Thus, it becomes more and more obvious that focusing on consumer needs and developing solutions that fulfil these need in an elegant, attractive and sustainable way might be the way forward for companies, designers and consumers alike to support the shift to urgently needed more sustainable production and consumption systems.

The following two paragraphs introduce a classification and several new and successful examples for such new business ideas and models.

### 3. Categorisation of Product-Service-Systems

Various classifications of product-services have been proposed (e.g. Behrend et al. 2003; Brezet et al, 2001; Zaring et al. 2001). Most classifications make a distinction in three main categories of PSS. Product-services are literally seen as a mix of a (tangible) product and a (intangible) service; the different types of product services differ in the extent to which their value is determined by the product- or the service component (see figure 1). They each also are a more radical deviation from the traditional product sales concept:

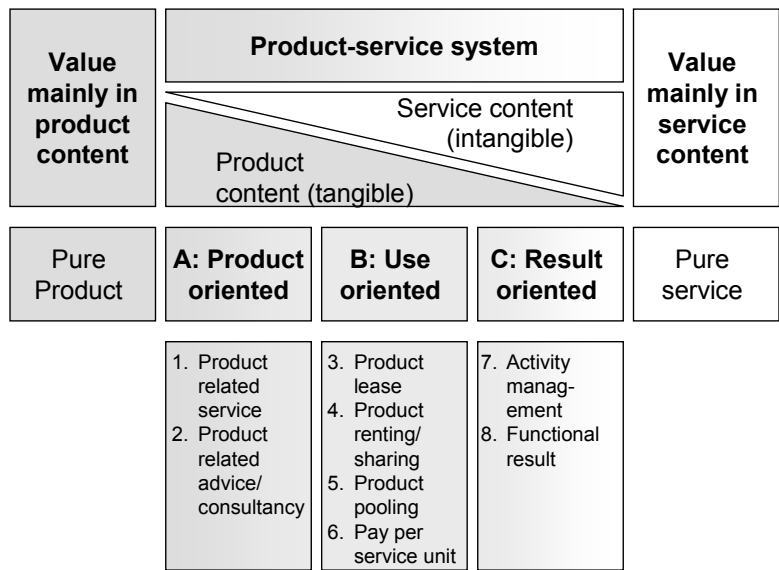
The first main category is **product oriented services**. Here, the business model is still dominantly geared towards sales of products, but some extra services are added like product take back, repair and maintenance or financing options.

The second main category is **use oriented services**. Here, the traditional product still plays a central role, but the business model is not anymore geared towards selling products. The product stays in ownership with the provider, and is made available in a different form, and sometimes shared by a number of users. Examples are car sharing, pay per wash or ski rental.

The last main category is **result oriented services**. Here, the client and provider in principle agree on a result, and there is not a pre-determined product involved. Energy contracting models, or natural pest control services belong to this category.

For product-oriented services, the property rights of the product are transferred totally to the user; for use-oriented services, the user buys access to a product (which stays in ownership with the provider) and for result-oriented services the user buys a result (without that any pre-determined product, let alone property rights are involved).

Figure 1 - Categorization of product-service-systems



The classification in this figure allows for a logical grouping of virtually all types of value propositions that one can think of, including ‘immaterial’ offerings such as (non-product related) advice and consultancy (which is a pure service). In addition in all categories we can distinguish business to business models (b2b) and business to consumer offers (b2c). The underlying assumption is that the more one moves to the right in the figure the less material product and thus consumption is involved and the more the immaterial service quality gains importance. However, as with any simplified classification system, there are exceptions for which this classification does not work well. The classification assumes that ‘products’ by definition have a material character, and for some products – most notably software – this is simply not the case.

**4. Case Studies and Models**

There are some very well researched and relatively common product-service-systems in practice that can be used as mainstream case studies:

From Interface Flooring offering the service of a nice floor instead of selling carpet tiles and reuse/ recycle all materials in a closed loop system, to Chemical Leasing systems where complete production steps such as surface coating of metal parts are outsourced to a separate provider who controls and delivers the desired result of the production step as a service to the client (the producer) and organizes it in the most efficient and safe way. There is a long tradition of all sorts of sharing, pooling, rental and leasing systems where the user only uses and pays for the use of a product for a specific period of time and the product can be used by several users subsequently or at the same time, like for cars, bikes, electric power tools, lawn mowers, agricultural equipment, baby prams and clothing, seasonal sporting equipment etc. Meanwhile by digitalisation several material products have been substituted by services such as the physical answering machine has been replaced by digital message recording services or archiving information has been replaced by ‘Cloud computing’; physical records and CDs/DVDs are no longer needed as we download our music and films digitally etc.<sup>1</sup>

<sup>1</sup> For these digital services the question still needs to be answered, whether the increase in energy consumption and digital equipment is more or less sustainable than the production, use and disposal of the physical devices substituted. However with the replacement of non-renewable by renewable energy sources the energy consumption might become less of a sustainability problem.

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More unconventional and newer models are for instance the following:

- Community Supported Agriculture / CSA, Organic Food Coops, Food Subscription Schemes and other food related systems:

The goal is to bring producers and consumers of food closer together and reintroduce our connection to healthy and local food that got lost in the phase of intensive industrialization of food production. Consumers can buy shares or actively get involved in growing and harvesting of food produce. Similarly the Farm Bags or Food Subscription systems allow farmers to calculate with a guaranteed income and (direct) sales while the consumers can expect the delivery of fresh, local, seasonal and mostly organic products each week. In addition there are cooperatives of consumers that grow their own food in community gardens or organise joint purchase and thus lower prices for the high quality, local, organic food. More and more of these models are emerging all over the world, as consumers realize that the food they buy in the supermarket might neither be healthy nor sustainable.

- Energy Service Companies / ESCOs and other energy related systems:

Under the terms of 'Least-Cost-Planning' or 'Contracting' and now 'ESCOs' several interesting new services in the field of energy efficiency and production are emerging. An ESCO is a service provider that takes care of energy (and financing) services for consumers or companies for an agreed price and tries to organize the delivery system of the desired energy based functions, such as light, heating, ventilation, cooling, hot water etc. and/or energy production in the most energy and thus cost efficient way. The income generated over time by reduced energy cost due to the optimized system versus the fixed price agreed on with the client makes up the income of the ESCO. ESCOs can also finance investment in better energy technologies and get the return over time by harvesting the energy savings in the system. These kinds of service offers that pre-finance system improvements and gain revenues by increasing efficiency in the system can also be imagined for water or mobility services.

- Fashion Swopping and Brand Hacking, Second Hand and Fashion Libraries

Resource consumption, pollution and waste generated by fashion industry and consumers is incredibly high and still growing, as is the awareness of industry and consumers that there might be a limit to fast fashion consumption. In addition consumer's satisfaction might not be in line with the material throughput in the fashion production consumption system. Thus several new concepts are emerging that do away with over-consumption and involve consumers in fashion design, production and provision. Second hand sales of clothing is a classic model but now libraries for high fashion goods are emerging that rent out high quality expensive garments. While this is still a commercial model consumers start meeting up for fashion swops organised via social networks (e.g. [www.clothingswap.com](http://www.clothingswap.com)) an simply exchange clothing in a barter economy model. More and more consumers who are unhappy with the branding hype start producing their own fashion designs using used clothing or imitating in an ironic way the well known fashion brands, and some are selling their creations via social media sites like Etsy ([www.etsy.com](http://www.etsy.com)). This is in line with a whole new DIY and 'Maker' movement. With the emergence of simple Computer Aided Design (CAD) software tools and small and reasonable priced rapid prototyping machines consumers start designing their own products and produce them at home for their own use or to sell them to others (see e.g. <http://makezine.com/>).

- Social Innovation models and Local Exchange Trading Schemes / LETs systems

Outside of the existing monetary economy more alternative 'business' models are evolving such as local networks of people who like to exchange service or product against service or product without paying in a regular currency. These systems are mainly created as ways to revitalise local communities especially in areas where poverty and unemployment is an issue and citizens are struggling to survive in the mainstream economy. Also more and more creative groups, activists and



professionals participate in these systems (see e.g. <http://www.letslinkuk.net>). The system normally provides an alternative currency or way to account for services and products members provide and gain so that a fair barter system can be organised.

Without any involvement of companies and commercial interest consumers start systems that can be summarized under the headline of social innovations such as teaming up to grow food together (community gardens), take care of children and take them to school (walking bus), help neighbours out with tools and randomly used products (community tool library), collecting food leftovers and producing meals for the elderly or the homeless etc. Most of these systems start among a group of likeminded friends or neighbours or an Internet community and once they are successful often are transformed into a non-profit or for-profit organisation.

The way these new models are starting off and growing is different depending on the initiators involved and the types of new system. Very often it is more difficult for existing mainstream companies to start a radical new model because of the existing infrastructure and organisation that might be averse to change. In this case the new business model might be initiated as a new branch/ daughter of the existing company. Often mainstream companies also purchase start ups to enter in a new market and business model.

The opposite is the case for start up companies that begin their business with a new business model and system that is directed towards sustainability (so called socio-preneurs)<sup>2</sup>. While they have all the freedom to design the new system, they might lack the experience and investment capital needed. These start ups meanwhile have a whole new realm of financing opportunities and support services available such as crowd-funding (see e.g. kickstarter, [www.kickstarter.com](http://www.kickstarter.com) or the German seedfunding organisation Seedmatch, [www.seedmatch.de](http://www.seedmatch.de)), where the community (the crowd) is invited to invest in the new business idea and depending on the pre-defined amount needed a new idea can be realised once the necessary budget is reached. Micro-financing/ Micro-Loan is another interesting support system especially for very small start-ups and especially in economically difficult regions (such as developing countries). The investment in micro loans can happen via traditional financial institutions or foundations but can also happen via crowd-funding. For instance [www.kiva.org](http://www.kiva.org) is a platform that connects lenders with small business projects starting with an investment per lender as low as 25\$.

### 5. Important Aspects of more Sustainable new Product-Service Offers

To conclude, there a lot of drivers and very interesting new business and social innovation ideas, models and movements emerging that start with the core motivation of improving quality of live and the environmental, social and economic sustainability of our way of living and our way of producing and consuming. Although some of them exist already for a very long time and some of them have been traditional models that got lost during industrialisation, we have merely seen the tip of the iceberg in terms of what is possible.

Important aspects in these approaches are:

- a) Several parties (companies, consumers, citizens, GOs and NGOs) collaborate in delivering product-service-systems, new alliances are created, ways to organize them effectively need to be established.
- b) The distinction between producers and consumers gets blurred especially in co-creation models, consumers become co-producers or the only producers that start providing to others.
- c) Return on investment for the providers can be more long term, thus new financing schemes are established.

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<sup>2</sup> In the US the socio-preneur movement is supported by a new legal form for these socially and environmentally beneficial businesses, the BCorporation see <http://bcorporation.net/>

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- d) Initial cost for the consumers/clients can be lower than when buying products, thus more expensive technologies and products become more accessible.
- e) The value creation and proposition (tangible and intangible) in the system is extremely important in two ways: as a starting point for the providers (“How can I offer most value for the clients?”) and as an effect and satisfaction of the system for clients (“This is a very individual service created especially for me and/or I even have participated in the creation of it.”)
- f) The profit in the system is closely related to offering the best service/ function continuously at lowest effort in terms of cost, resources and energy – not necessarily time.
- g) Starting point for these systems can be social innovation without any company involved, like car sharing originally started among a group of neighbours.
- h) During up scaling and maturing normally some kind of (for-profit) organization is formed to run the product-service-system in an efficient way.
- i) New financing schemes such as crowd funding and micro loans are used more and more to generate the initial funding for the new offers.
- j) Organizations often start small in niches and then up-scale and/or multiply the model.
- k) There is a challenge of keeping the character, quality as well as human scale and sustainability in the system during the process of growth.
- l) Not all product-service-systems are automatically sustainable. Sustainability has to be designed into the system carefully.

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## Trash to Treasure

Kresse Wesling

Co-founder and Director

Elvis & Kresse

Poole

UK

Waste has been a life-long interest, if not obsession, for Elvis & Kresse. Co-founder Kresse Wesling is passionate about finding uses for industrial waste and turning ideas into stylish, well-made and sought after products. As a venture capitalist Kresse worked on waste related products in the UK and Hong Kong, before meeting the London Fire Brigade in 2005 and learning of the huge amount of unrecyclable fire hose that ends up in landfill every year. Elvis & Kresse now convert fire hoses into belts and bags which are sold in Harrods and have been modeled by Cameron Diaz in American Vogue. Nobody had made anything from fire hoses, so Elvis & Kresse had to invent a way of dealing with it. A long process of 'trial and error' followed. Eventually after much experimentation, they were able to persuade a factory in Romania to take on production. The range now includes wash bags, floor tiles, customizable cufflinks and place mats. Elvis & Kresse help the Fire Brigade save the landfill fee, but they also donate 50 per cent of the proceeds from the products to the Fire Fighters Charity; it is a long-term, reciprocal relationship. As Kresse says, "It is a question of patience, and waiting to find the right materials" and it is also about having the skill and artistic ability to make it all happen!



## The Centre for Sustainable Design<sup>®</sup>

For more more information, please contact:

Martin Charter  
Director  
The Centre for Sustainable Design  
University for the Creative Arts  
Falkner Road  
Farnham  
Surrey GU9 7DS  
UK  
Tel +44 (0)1252 892772  
Fax +44 (0)1252 892747  
Web [www.cfsd.org.uk](http://www.cfsd.org.uk)

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