Design for Sustainability:
Moving from Incremental towards Radical Design Approaches

Marcel Crul, Ph.D., M.Sc.[1]
Jan Carel Diehl, Ph.D., M.Sc.

Delft University of Technology, Faculty of Industrial Design Engineering.
Landbergstraat 15 2628 CE Delft, The Netherlands. Email: m.r.m.crul@tudelft.nl

'Transitions to Sustainability', NZSSES conference 2010, Auckland New Zealand

Abstract

The concept of *Design for Sustainability (D4S)* goes beyond how to make a 'green' product and strives to meet consumer needs through sustainability-oriented interventions in a systematic and systemic way. It covers strategies ranging from incremental to radical innovation and from a focus on the individual product to an integral systems view.

Practical approaches for industry, showing effective solutions and direct sustainability benefits are at the heart of the D4S approach. It can be used in a collaborative process with several partners, either within a company, or in a project where a broader partnership of both intermediates and companies are involved.

The key inside-the-box, incremental innovation strategy is *D4S Redesign.* This strategy is aimed at sustainability-driven, stepwise improvement of an existing product. A closely connected approach, D4S Benchmarking, advocates learning from competitors' efforts and experiences to improve a company's own products, and is especially suitable for companies that develop products by imitating existing products.

The incremental strategies are very relevant and useful, but out-of-the box or radical sustainable product innovation strategies are necessary to achieve significant sustainability gains.

D4S New product development involves a higher level of technical, market and organizational uncertainty then redesign, at the same time a higher sustainability gain can be reached. New product development is strongly connected with system innovation, which is typically accompanied with radical changes in technologies, regulations, user practices, markets, culture, infrastructure and supply networks.

Another radical approach is the development of *D4S Product-Service Systems* (PSS). This strategy stems from the fact that services and products are becoming more and more intertwined. If properly designed, PSS can be much more sustainable then purely product-based solutions.

This paper describes the theoretical and methodological development of the D4S concept, and presents several industrial cases.

1. Introduction

It is increasingly apparent that current patterns of consumption and production are unsustainable, as evidenced in the ever increasing rate of adverse environmental and social impacts. The accelerating processes of globalization and trade liberalization, supported by

[1] Corresponding author

advances in information technologies, have fundamentally changed the landscape of the private sector in both developed and developing economies, providing new opportunities to improve sustainability. Companies are improving the efficiency of current production and the design of new products and services. These profit-driven strategies go by many names, such as Ecodesign, sustainable product design and more recently, Design for Sustainability (D4S).

In the 1990s, concepts such as Ecodesign and green product design were introduced as strategies companies could employ to reduce the environmental impacts associated with their production processes (Brezet and van Hemel 1997). To keep pace with the rapidly changing industrial setting, many environmental movements have expanded their scope to include social and economic concerns. These environmental, social, and economic priorities are the three pillars to 'sustainability.' Sustainability can be defined as "the possibility that humans and other life will flourish on the Earth forever" (Ehrenfeld 2008).

Ecodesign has evolved to include both the social and profit elements of production and is now referred to as sustainable product design or 'Design for Sustainability' (D4S). D4S goes beyond how to make a 'green' product and embraces how to meet consumer needs in a more sustainable way. Companies incorporating D4S in their long-term product innovation strategies strive to alleviate the negative environmental, social, and economic impacts in the product's supply chain and throughout its life-cycle. The D4S concept now embraces both incremental (redesign) and radical (new products, product-service systems) product innovation to achieve the necessary sustainability gains.D4S essentially integrates these approaches and aims to drastically improve the efficiency and social qualities of production processes by developing new products, services, and systems alongside on-going continuous improvement of products.

2. The need for radical design approaches

Sustainability requires taking the needs of future generations into account, which means future environmental and social concerns need to be addressed. Global environmental pressures are directly related to the size of the population which helps define consumption levels, and the materials and energy required to produce each 'unit' of consumption. It has been estimated that environmental pressures should be reduced by about half. Taking into account the current growth rate of developing economies, the efficiency of products and processes needs to be improved by a factor of 4. Future generations could be living in a world with a population of 9 billion, and much higher consumption levels, which would require materials and energy improvements by a factor of 10 to 20. This type of 'factor thinking' or 'factor X thinking' (von Weizsäcker et al., 1997; Factor 10 Club, 1997; NIDO/KSI, 2003) shows the magnitude of the task at hand, and the critical need to improve production processes, products, and systems.

More recently, this notion of decoupling economic growth and use of resources by factor efficiency improvements has been fundamentally criticized as being unrealistic. Jackson (2009) gives the example that with sustained economic growth, carbon intensity in 2050 should be a factor 130 lower than today, a truly daunting factor of improvement to be achieved. The need for a radical change of society towards sustainability, challenging the necessity of economic growth as the basis for prosperity, is expressed in several influential publications (Ehrenfeld 2008, Jackson 2009). A new kind of prosperity is proposed, based on human flourishing in far less materialistic ways. As John Ehrenfeld (2008) notes in *Sustainability by Design*, we still have the opportunity to change our unsustainable habits, but we can no longer afford to take our current consumption patterns for granted. A consumer

demanding cleanly-produced products might feel good about his or her lifestyle choice, but it will take more than just consuming such products to initiate a change – it will require a decrease in consumption as well in order to realize any gains.

Short-term incremental redesign of existing products, also called 'inside-the-box' innovation, can typically lead to improvements up to a factor 5. To achieve long-term factors of 10, 20 or higher, or changes towards radical shifts in the whole of society, radical product innovation, or outside-the-box innovation, is necessary. This includes developing completely new products, improving products as well as the services connected to them, and developing entirely new functional systems of products and services. Before going into the details of these different D4S approaches, a short description of the different types of innovation is given.

2.1 Incremental and radical innovation

Product innovation is essential for industry's competitive position as well as for a country's economic growth. Companies operate in a rapidly changing world in which customer needs and wants are not fixed and industry faces increasing competition due to open markets and globalisation. Companies that effectively integrate innovation into their product development process can gain a significant competitive advantage. Innovation is a broad concept that is used in many different contexts. As a result, there are many definitions of innovation. One useful definition is: "*the commercial or industrial application of something new– a new product, process or method of production; a new market or source of supply; a new form of commercial, business, or financial organisation*" (Schumpeter, 1934). Baregheh et al. (2009) within an organizational context, define innovation as: *"the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace."*

Innovation can be categorized in many ways. OECD (2005) discerns 'new to the firm', 'new to the market' and 'new to the world' types of innovation, and connected to this 'radical or disruptive' innovation. Miller and Morris (1999) have developed a conceptual division of continuous or incremental and discontinuous or radical innovation. Abernathy and Utterback (1978) and Utterback (1994) emphasize the importance of radical innovation and discern between incremental, modular, discontinuous and fundamental innovation.

Based on these different typologies, we divide innovation into three levels: incremental, radical, and fundamental. Each category is progressively more significant and far-reaching.

Incremental innovation entails step-by-step improvements of existing products and tends to strengthen market positions of established companies in the industry. This includes benchmarking approaches in which products of competitors are copied and/or improved.

Radical innovation drastically changes existing products or processes. The risks and investments required for radical innovation are usually considerably greater than those needed for incremental innovation but offer more opportunity for new entrants to the market.

Fundamental innovation depends on new scientific knowledge and opens up new industries, causing a paradigm shift. In the early stage of fundamental innovation, the contributions of science and technology are important.

Fundamental innovation often takes place only in large multinational companies, company clusters or national and international research programmes because of the large human and capital investment needed. The majority of companies engage in incremental or radical innovation efforts.

2.2 Inside-the-box: Incremental innovation

Incremental innovation is sometimes referred to as continuous improvement, and the business attitude associated with it is 'inside-the-box' thinking. A simple product may be improved (in terms of better performance or lower costs) through the use of higher performance components or materials. A complex product that consists of integrated technical subsystems can be improved by partial changes to one level of a sub-system. Incremental innovations do not involve major investments or risks. User experience and feedback is important and may dominate as a source for innovation ideas. As an example, customer preferences can be identified and added as features to the existing product.

Incremental innovation and design improvements are known as the 'bread and butter' of product innovation for many firms. Many firms do not even attempt to explore radical innovation for a variety of reasons having to do with their size and resources, the nature of the industry, the level of research and development required, or the amount of risk involved. Even firms that successfully introduce radical innovation may not do so very often. Incremental innovation projects, due to the low-level of involved risk usually follow a structured and predictable process.

2.3 Out-of-the-box: Radical innovation

Radical innovation involves the development of new key design elements such as change in a product component combined with a new architecture for linking components. The result is a distinctively new product, product-service, or product system that is markedly different from the company's existing product line. A high level of uncertainty is associated with radical innovation projects, especially at early stages. Technical, market, organisational, and resource issues all need to be addressed.

Two primary types of radical innovation are:

- New-to-the-Market: Novel substitutes, based upon new products to society;
- Breakthrough: Significantly changes the existing industry or creates a new business.

Ansoff (1968) included these two types in the 'out-of-the-box' approach. It means that the idea is based upon (1) a new technology or product; or (2) it is new to the market; or (3) both. Product innovations based on a new technology or product and new customers have the highest risks not to be adopted in the market.

In many cases, established companies are not able to create new-to-the-market or breakthrough solutions, because they would potentially jeopardise the existing business model and/or industrial infrastructure itself. Therefore, radical product innovation usually requires an 'outside-the-box' approach. Outside-the-box innovation aims to create an approach that goes beyond existing business models and links with other companies to create a new venture. The risks involved are significantly higher and the time horizon also tends to be much longer.

3. Incremental and radical D4S approaches

3.1 A systematic design approach

A company that wants to innovate its products or services needs to know what to do and how to do it. A basic systematic approach for this has been developed by Roozenburg and Eekels (1995) and consists of four basic steps (see figure 1): Formulating goals and defining strategies for product development based on market perceptions; generating and selecting

ideas for the new or improved product; developing these ideas into the blueprint of the new product; and transforming the plans into reality including production, distribution, sales, use and end-of-life of the product. Of course an actual product innovation process will often be more chaotic, iterative and less linear than described here, nevertheless the fundamental steps can usually be recognised and are necessary for successful innovation.

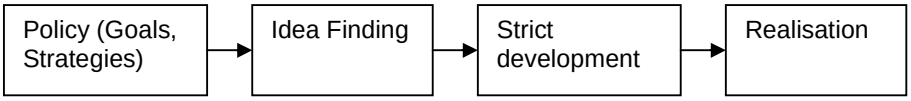

Figure 1: Basic steps for Product Innovation (Roozenburg and Eekels 1995)

In the next part of this paper, approaches are presented for both incremental and more radical product innovation. Although the different types of sustainable product innovation (redesign, new product development and product-service systems) all have their own specific requirements and issues, the basic four steps shown in figure 1 can be recognized in all of them, thus connecting them into one 'family' of systematic product innovation approaches.

In figure 2 the detailed steps of three main design approaches redesign, new product development and product-service-systems are depicted, clearly showing the basic four steps in each of them (Crul et al. 2009).

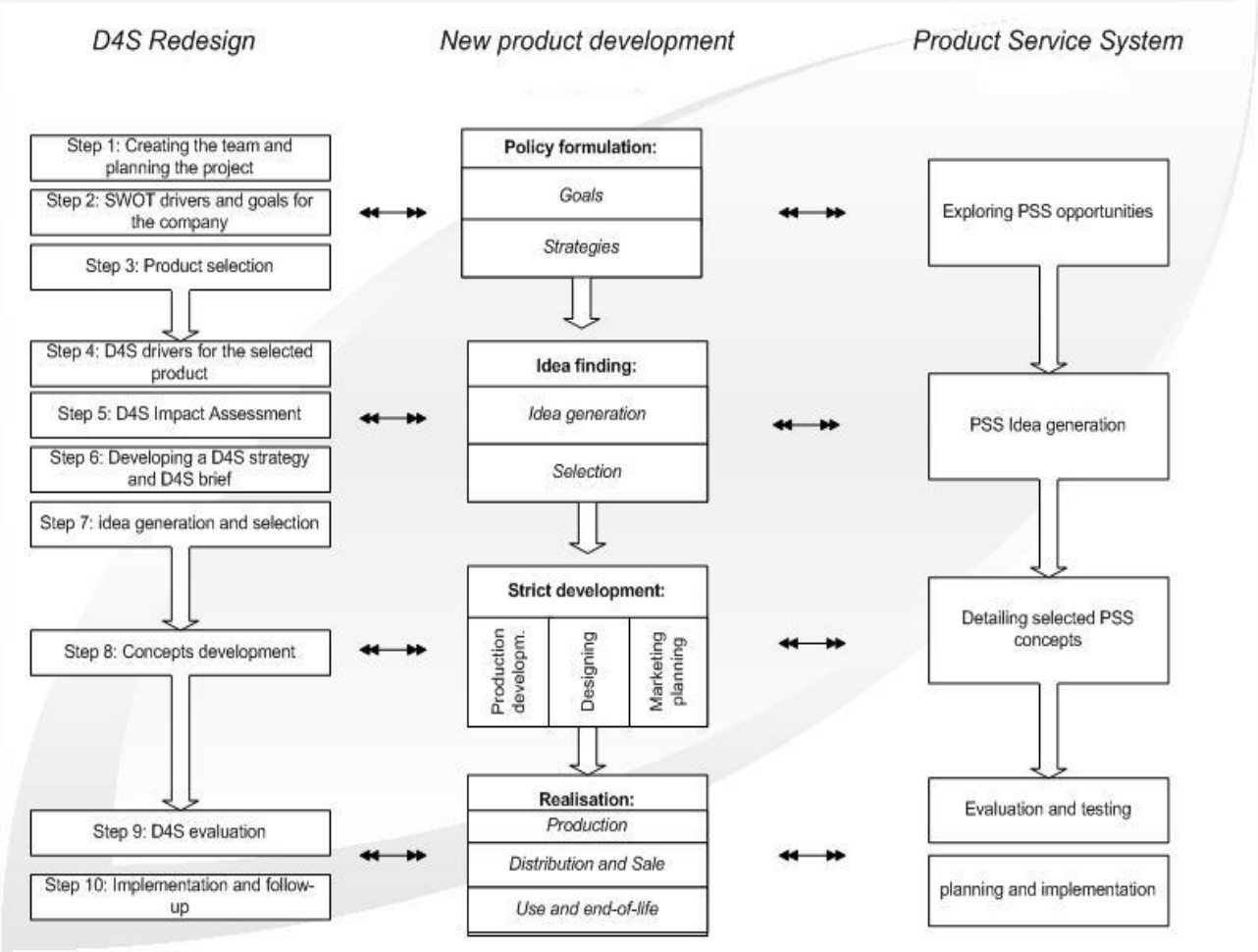

Figure 2: The three parallel D4S approaches redesign, new product development and PSS

3.2 D4S Redesign approach

D4S Redesign, as the name implies, aims at redesigning an existing product made by a company (or by a competitor) from a sustainability point of view. Redesign is an incremental, or inside-the-box, type of product innovation and typically involves smaller risks and investments. It follows a structured and predictable process and for many companies is economically and commercially as important as more radical approaches. Because the focus of D4S Redesign is an existing product, the market and manufacturing conditions specific to the product are already known. Its improvement potential can be determined from easily accessed information – such as feedback from the sales department, user experiences and testing and market investigations. In addition, the existing production facilities are usually suitable for manufacturing the redesigned product and hence, investment costs would likely remain within reasonable boundaries. The risks connected with the redesign effort are lower compared to more radical D4S innovation approaches that are described below.

The D4S Redesign approach can be organized in 10 consecutive steps, as illustrated on the left side in the figure 2. These steps can be grouped according to the 4 basic steps for product innovation (goals & strategies, idea finding, strict development and realization). In each of the steps specific tools and approaches related to the sustainability of the product are integrated into the process. Examples of such tools are the D4S impact assessment matrix, and the use of systematic D4S strategies in steps 6 and 7, as well as rules of thumb for improvement options. The finished, redesigned product should be compared against the initial product to consider and estimate the sustainability advantages of the new product versus the original; after the product is launched, the company must do follow-up to evaluate overall sustainability, which will spawn new implementation ideas for future products.

A closely connected approach, D4S Benchmarking, advocates learning from competitors' efforts and experiences to improve a company's own products, and is especially suitable for companies that develop products by imitating existing products. The methodology for benchmarking is closely connected to redesign.

Case Study D4S Redesign: Truong Thanh Furniture Corporation (TTFC) in Vietnam

Truong Thanh is a leading Vietnamese company in wood product manufacturing and exporting. It is constituted of eight factories employing a total of 9,000 employees. The company joined the CP4BP project in Vietnam on D4S, executed by the Vietnamese Cleaner Production Centre in cooperation with TU Delft. 97% of their products are exported. TTFC has a total of 23 designers which design 80% of their products in house and have a sales staff of 30 people. The company has its own research and training unit and produces 40% indoor furniture, 50% outdoor garden furniture, and 10% flooring.

The Venice Folding Barbeque (BBQ) bar was selected for D4S demonstration. Market research showed that in many of the countries where this product was being exported to, consumers enjoyed spending time outdoor organizing various social events which combine outdoor entertainment with dining. The Product Innovation Team together with the D4S experts decided to redesign the Venice Folding Bar into a convenient and fully utilized bar and kitchen stand. This product was subject to the following improvements (figure 3):

- 40% of this product is now made from leftover wood from other production processes;
- Use of wood in the product has been reduced;
- All wood used has Forest Stewardship Council Certificate;
- The BBQ functions have been increased and accessories added to increase the usability and therefore the value of the product;

- the size of detailed parts was reduced
- The new bar is foldable for easy transport and storage.

Figure 3. BBQ bar before project BBQ bar after project implementation

---

3.3 D4S New Product Development

The D4S new product development approach applies “out-of-the-box”, or radical, innovation strategies, which can lead to more sustainable impact while providing the breakthroughs necessary to ensure an company’s continued competitiveness. New product development involves a higher level of technical, market, and organizational uncertainty than redesign but can be an inventive and iterative process where new ideas on how to meet needs are converted to products and services. Eco-friendly materials, sustainable development practices, and innovative information and communication technology are all concepts that can help inspire new product design. As consumer needs and expectations evolve, new products and services offer opportunities to enhance product portfolio sustainability including addressing increasingly important social concerns.

The stages and processes involved with new product design can be viewed as four-fold: policy formulation, idea generation, product development and realization (see middle part of figure 2). Policy formulation addresses the company’s goals and strategies; idea generation allows the company to brainstorm and develop ideas for new products, taking into account the ability to harness developing technologies, materials and consumer needs; product development involves debating and testing concepts against the decisions in the idea finding phase. The key challenge with respect to new product design is market demand. Without a consumer need, even the most sustainable product will fail. Finally, realization takes place in a parallel development of production, marketing planning, planning of distribution, sales and the later phases of use and end-of-life. In contrast to redesign, no clear rules-of-thumb can be defined for new product development, hence the more open and innovative ‘idea finding’ phase is included in the approach.

Case study D4S New Product Design: Kamworks, Cambodia

Kamworks is a solar company in Cambodia. Cambodia receives on average five solar hours a day, so Kamworks saw the country’s solar capacity as an opportunity for local production of solar lighting products that fit the purchasing power of rural households. After an initial analysis and development of a solar lantern, Kamworks contacted TU Delft to work on a series of projects that covered the total design phase of a mobile lighting product from market analysis to final prototype.

Many people in Cambodia use kerosene fuel lamps as a mobile light for purposes in- and outside the house. The light is not very bright, the lamp cannot be used in windy or rainy conditions, and fuel costs are high. For the most recent Kamworks lighting project, the goal was to provide a sustainable lighting solution for low-income rural households, the vast majority of which do not have access to the public electricity grid. The Delft design team came up with several recommendations, including the need for a durable, shock-proof lamp that was portable and could completely replace the traditional kerosene one. On the basis of this, a series of possible new designs for lamps was developed, and the “MoonLight” was chosen as the final prototype.

The design is intuitive and easy to use. The final design has a triangular shape and includes a cord that is attached at the three corner points (Figure 4). It mainly consists of two vacuum-formed outer shells and two also vacuum-formed blisters that hold the electronics together and buffer them at the same time for possible shocks.

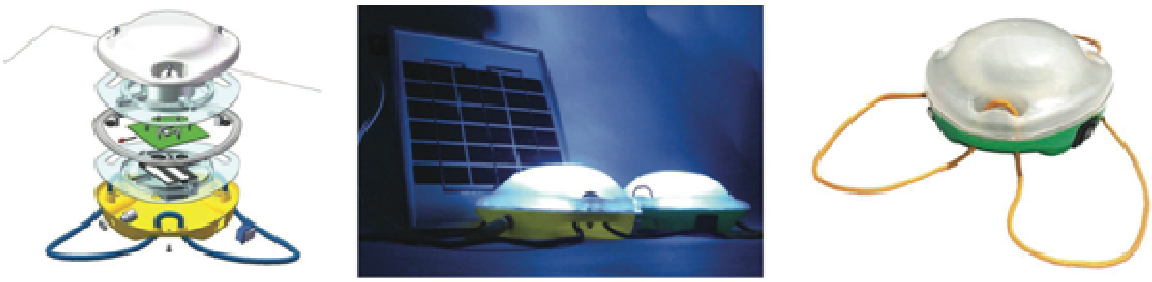

Figure 4. The Kamworks prototype “MoonLight.” Exploded view, 3D rendering and in practice

---

The MoonLight can be hung from wall or ceiling, carried by hand or hung around the neck, and has six wide-angle LEDs, which give equivalent light output of about four kerosene lamps. It comes with a solar panel for easy charging (Diehl and Kuipers 2008). The product’s ease of use and simple design gives Kamworks high hopes that the MoonLight will be revolutionary in rural Cambodia. The product had its market introduction in 2010.

3.4 D4S Product-service systems (PSS)

PSS illustrate the movement towards more radical forms of D4S because they use different ways of addressing at the design stage what a customer really needs and the way a product is designed, produced, used and discarded. PSS can be an effective function-based strategy that concentrates on "satisfaction" as a product value instead of private ownership of physical products, a traditional standard of wellbeing that exists in many industrialized contexts. Sustainable innovation and design is not necessarily about new technologies, but about rethinking how to meet everyone’s needs of sustaining growth without costly environmental and social impacts.

The concept of PSS proposes that companies move from merely selling products (or services) to designing and providing *a system of products and services* (and related infrastructure) which are jointly capable of fulfilling client needs or demands more efficiently and with

higher value for both companies and customers than purely product based solutions (Tukker and Tischner, 2006).

Increasingly, economic value lies less in the product itself than in other parts of the product-system that can be called product-related services. Current ink-jet printers, for example, are sold at a discounted price because of the future income to the manufacturer that will come from the sales of ink cartridges. PSS, as a strategy for innovation, can be thought of as widening the focus for design and development to coordinate – and re-configure – a set of products and services for a new business system to meet customer needs in a more economical and environmentally efficient way.

Before trying to restructure a whole organisation or found a new company or organisation with a new business idea, it makes a lot of sense to run through a pilot project. The pilot project will assist the company in the following five phases (Tischner, Ryan et al. 2009) (see right hand side of figure 2):

1. Exploring opportunities, identification and analysis of the existing reference system,
2. PSS idea generation and selecting the most promising concepts
3. Detailing selected PSS concepts
4. Evaluation of detailed PSS concept(s) and testing
5. Planning implementation.

The actual implementation, management and control of success will be done after the pilot project if the companies decide to realize the new solution. This is very company, consortium and solution specific.

The five phases correlate with the four basic steps for product innovation whereby the last two PSS phases (evaluation and planning of implementation) can be seen as detailing of the fourth product innovation step ‘realisation’.

Not all shifts to PSS result in environmental benefits and/or economic or social advantages. A PSS must be specifically designed, developed and delivered, to be sustainable. For example, schemes where products are borrowed and returned incur transportation costs (and the resultant use of fuel, and emissions). In some instances, the total fuel cost and environmental impact may make the system less sustainable than a product sales concept.

Furthermore, even when well-designed, some PSS concepts could generate unwanted side effects, usually referred to as “rebound effects”, i.e. counterproductive effects that “eat up” the intended positive sustainability effects. For example, outsourcing, rather than ownership of products, could lead to careless (less environmentally responsible) behaviour, e.g. the benefits of a small and more fuel- therefore cost-efficient car can lead to more driven kilometres, simply because it is convenient and cheaper even in a car sharing system.

Nevertheless, PSS development certainly presents a potential for generating win-win solutions, which promote economic, environmental and social benefits. They have the potential to provide the necessary, if not sufficient, conditions to enable communities to leap-frog to less resource intensive (more dematerialised) systems of social and economic benefits.

Case study D4S Product Service System: Textile Flooring

Diddi & Gori S.p.A. is an Italian company specialised in producing manufactures for shoe industry and textile flooring. The production of synthetic fibres and chemical products implies oil refining with obvious consequences for the environment. For this reason, Diddi & Gori’s goal is to create manufactures without chemical products or completely recyclable, involving a lower use of raw materials.

Digodream is the product-service offered by Diddi & Gori. It consists of textile flooring that can be used during trade fairs and exhibitions, made of waste and completely recyclable, since it returns as the original fibre. The novelty of Digodream is that it is sold as an entire service, from the supply and the installation to the removal. It has become a whole system of services given to the client, who is no longer owner of the product, but buys its utility. Hence, the new concept of product is clearly moved from the traditional one to the idea of mutually dependent products and services that focus on the utility. Users do not demand the products or services, per se, but what these products and services enable them to achieve. In this perspective, the client obtains the needed utility and pays for product use. Prior to this, similar products were bought, used for a short period of time and then disposed. Digodream, after being used, returns to the producer, who recovers it to make fibres again.

4. Concluding remarks

In this paper, the options were discussed that a company or design office has to improve a product from a D4S point of view, starting from today's products. However, to achieve a long-term balance between economic, ecological and social-cultural dimensions in sustainable development at a global level, more radical approaches such as new product development or PSS are needed. A sustainable planet needs sustainable product innovation, including break-throughs and leapfrogging. In terms of eco-efficiency alone, not only factor 2-4 improvements that can be achieved with D4S redesign are needed but improvements of a factor 10-20 ('Factor X'), implying the same function fulfilment of product-systems but now using 5% of today's resources, implying almost zero waste and emissions over the life-cycle.

Practical approaches have been shown on redesign, new products and on Product Service Systems (PSS). Successful sustainable PSS are designed in such a way that the dematerialized product-service combination is adopted for its value by the end-user and profitable for the other actors in the chain.

D4S development of specific new, sustainable products that create superior overall sustainable systems is the ultimate challenge for every designer. For every actor in the field this is a personal or company/organization choice. There are different options to do so. One can buy –the best designed- existing products, adapt or redesign them yourself or one can go for radical new artefacts.

The ambition to invent and innovate systems by radical new products is not the easiest option to choose. Radical product innovation as such is already a difficult and –by nature- unpredictable process, so taking extra D4S demands on the sustainability aspects on board makes the process of product innovation even more complicated.

Just making production more sustainable does not guarantee environmental benefits. For example, a large increase in production efficiency coupled with a similar increase in overall production would mean no absolute environmental gain. If complemented with more sustainable personal lifestyle choices, D4S practices could be a key factor in a revolution in production and consumption patterns, providing opportunities for people to flourish in less materialistic ways.

The approaches discussed above, illustrated by the case studies, provide examples and experiences to inspire action and commitment to move forward, not just for producers but also for consumers. D4S is a concept in evolution, being one of the sustainable strategies to inspire new thinking about the entire circle of production and consumption.

5. References

Abernathy, W. and J. Utterback (1978). Patterns of Industrial Innovation. Technology Review, 80, pp 40-47

Ansoff, H. I. (1968). Corporate Strategy. Harmondsworth, Penguin.

Baregheh, A., J. Rowley and S. Sambrook (2009). Towards a multidisciplinary definition of innovation, Management decision, vol. 47, no. 8, pp. 1323–1339

Brezet, J. C. and C. G. v. Hemel (1997). Ecodesign: A promising approach to sustainable production and consumption. Paris, UNEP.

Crul, M., J. C. Diehl, and C. Ryan (2009). Design for sustainability - A step-by-step approach. Paris, UNEP.

Diehl, J.; Kuipers, H. (2008) Design for the Base of the Pyramid: Student Field Projects in Cambodia; Proceedings of *the Design ED Asia Conference*, Hong Kong, China.

Ehrenfeld, J. (2008). Sustainability by Design. London Yale University Press.

Factor 10 Club (1997). Statement to government and business leaders. Carnoules: Factor 10 Institute.

Miller, W. and L. Morris (1999). 4th Generation R&D: Managing knowledge, technology and innovation. Wiley, New York.

NIDO/KSI (2003). Knowledge Project NIDO/KSI. To a National Knowledge & Competence Centre for Transitions to a Sustainable Society. NIDO, Leeuwarden, the Netherlands.

OECD (2005) Olso Manual. Guidelines for collecting and interpreting Innovation Data. OECD, Paris.

Roozenburg, N. F. M. and J. Eekels (1995). Product Design, Fundamentals and Methods. Chicester, Wiley & Sons.

Schumpeter, J.A. (1934). The Theory of Economic Development. Harvard University Press, Boston.

Tischner, U., C. Ryan, et al. (2009). Product Service Systems. In: Design for Sustainability: A Step-by-Step Approach. M. Crul, J. C. Diehl and C. Ryan. Paris, UNEP**:** pp 95-104.

Tukker A. and U. Tischner eds. (2006). New Business for Old Europe. Product Services, Sustainability and Competitiveness. Greenleaf Publishers, Sheffield UK.

Utterback, J.M. (1994). Mastering the Dynamics of Innovation, Harvard Business School Press, Boston.

Von Weizsäcker, E., A. Lovins and H. Lovins (1997) – "Factor 4 - Doubling Wealth, Halving Resource Use". Earthscan.