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## **Design for Sustainability (D4S): Manual and Tools for Developing Countries**

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# Design for Sustainability (D4S): Manual and Tools for Developing Countries

## Abstract

*Design for Sustainability (D4S) is a globally recognised way in which companies can work to improve efficiencies, product quality and market opportunities and at the same time increase environmental & social performance - resulting in a win-win situation. Most of the current available D4S manuals and tools have been developed in West Europe, based upon European experiences. However, in developing economies needs are different and more immediate. Also the characteristics of the local companies and product innovation approaches differ because of specific local social, economical and industrial development aspects. Till to date only a few targeted efforts have been made to develop a tailor made D4S approach specifically for the context of product innovation in Developing Economies.*

*The Design for Sustainability (DfS) program of the Delft University of Technology (DUT) in collaboration with the United Nations Environment Program (UNEP) has launched a Design for Sustainability (D4S) manual targeted at especially SMEs in Emerging and Developing Countries in 2006 (Crul and Diehl 2006). Based upon the experiences of DfS and UNEP with Design for Sustainability in universities and companies in, among others, East Africa, Central America and India a manual and set of tools have been developed which fits into the context of small and medium sized enterprises in developing economies.*

*The approach and content of this Design for Sustainability manual for Developing Economies (D4S-DE) are currently applied and adapted in ongoing projects in Central America, Africa and South-East Asia. One case study of application will be discussed.*

**Key Words:** *Design for Sustainability, manual, tools, developing countries*

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## 1. Introduction

A major challenge for SMEs in Developing Countries is to innovate: initiate, or adapt fast enough to changes in the economic and commercial business environment. Doing this in a sustainable way means catering to human needs while maintaining the environmental and natural resources and local communities as a long term pre-condition for human societies. This approach is nowadays called 'Design for Sustainability' (D4S). D4S includes the more limited concept of Ecodesign or Design for the Environment. D4S is closely linked to wider concepts such as sustainable product-service systems, systems innovations and other life cycle based efforts.

### 1.1 The history of Design for Sustainability

In the late 1980s and early 1990s, sustainability largely was an environmental issue. Initially efforts focused on improving end-of-pipe technologies. The focus then shifted towards production improvements via concepts such as clean technology, cleaner production, and eco-efficiency. The next shift was to product impacts, thereby taking into account the whole product life cycle.

Concepts like Ecodesign and Design for the Environment (DfE) were developed and put into practice. In the next phase, the focus went beyond environmental issues only. Based on experience gained, Ecodesign evolved to encompass broader issues such as the social component of sustainability and the need to develop new ways to meet consumer needs in a less resource intensive way. Design for Sustainability (D4S) goes beyond how to make a 'green' product - the concept now embraces how best to meet consumer needs – social, economic and environmental - on a systematic level. These 3 key elements of sustainability are also referred to as *people, planet* and *profit* (3P). Design for Sustainability can be illustrated adding a fourth 'P', the one of Product (Innovation), to the

sustainability concept resulting in the '4P' approach (Boks and Diehl 2004). The difference in focus of Design for Sustainability and Ecodesign can be illustrated by figure 1.

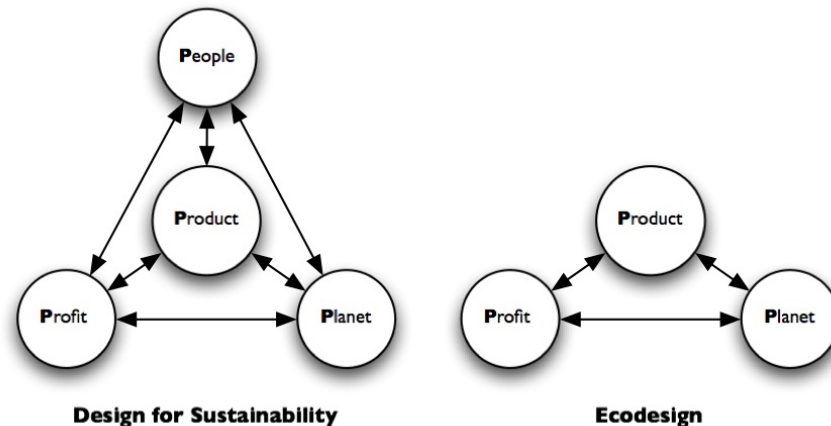


Figure 1: Design for Sustainability (D4S) versus Ecodesign.

It is expected that this inclusion of the social (people) aspects has made the approach more appropriate for Developing and Emerging Countries since they often have to face big social challenges as well like for example income generation, education and health problems.

Nowadays Design for Sustainability (D4S) is a globally recognized way in which companies can work to improve efficiencies, product quality and market opportunities and at the same time increase environmental & social performance - resulting in a win-win-win situation (Crul 2003; Crul and Diehl 2006). In many developed economies, because of a high level of awareness about the potential of efficiency and environmental concerns, D4S efforts are linked to wider concepts such as product-service mixes, sustainable innovation and other life cycle-based efforts.

## 2. D4S is Developing Countries

### 2.1 D4S projects in Developing Countries

In 1997 the Design for Sustainability program of the Delft University of Technology published the United Nations Environment Program (UNEP) Ecodesign manual (Brezet and Hemel 1997) based upon the experiences mainly in Europe and the United States. This 'Western' Ecodesign approach was a starting point for an exploration after the need for Ecodesign in developing countries and how to adjust it to the specific context. As a result the Faculty of Industrial Design Engineering of Delft University of Technology initiated several research programmes and demonstration projects related to D4S in developing countries:

- In Central America a four-year Ecodesign programme was performed from 1998-2002, leading to the (re)design of over 20 successful industrial products (metal, food, packaging, coffee machinery, furniture, plastics, tourism), the preparation of a regional manual and fact sheet set, involvement of local networks in several countries of the region and the building of local capacity at consultancies, universities and National Cleaner Production Centres. Since 2002, both in Costa Rica and Guatemala several follow-up programmes on Design for Sustainability have been initiated (Crul, 2003).  
See <http://www.io.tudelft.nl/research/dfs/ecodiseno/>
- In India, a three-year collaborative programme with European countries was completed in 2002, aimed at the promotion of Ecodesign, exchange of knowledge, and building of an Ecodesign network in Delhi and later in other parts of the country.  
See <http://www.io.tudelft.nl/research/dfs/sustainabledesign/>
- In East Africa a curriculum on product innovation was established at University of Dar es Salaam (UDSM) in Tanzania and a dozen product innovation projects were carried out in local industries. In addition needs assessments were made after the need for Ecodesign in Uganda, Tanzania, Kenya and Zimbabwe.  
See <http://www.io.tudelft.nl/research/dfs/ide-conference/>

- Recently, D4S projects are ongoing in industry in Brazil, India, China, Morocco, Costa Rica, Vietnam, Lao and Cambodia; all are connected to the D4S in Developing Economies manual (Crul and Diehl, 2006). See for instance //www.cp4bp.org/

### 2.3 Differences for Design for Sustainability in Developing Countries

While there is considerable experience accumulated in the field of product innovation in developed countries, much of this is not directly applicable to developing countries because of the nature the latter are facing. Innovation climates in developing countries are, by nature, problematic, characterized by poor business and governance conditions, low educational levels, and mediocre infrastructure. This raises the particular challenges for the promotion of innovation in these contexts (Aubert 2004; Chen and Dahlman 2004).

The same counts for Design for Sustainability. Most of the current available D4S manuals and tools have been developed in West Europe, based upon European experiences. However, in developing economies needs are different and more immediate. Also the characteristics of the local companies and product innovation approaches differ because of specific local social, economical and industrial development aspects. Till to date only a few targeted efforts have been made to develop a tailor made D4S approach specifically for the context of product innovation in Developing Economies.

For example in developing countries often micro, small and medium enterprises companies dominate in the economy as well as in the labour market. Habitually it lacks a structured product development process in these SMEs, they possess of relatively low educated staff and they mainly operate in low-tech sectors like food processing, metal processing and furniture (Kogut 2003). This specific regional setting requires a different Design for Sustainability approach compared to the industry in the Western World.

Based upon our experiences with Design for Sustainability in developing countries we have adapted the Design for Sustainability for Developing Economies manual on the following aspects to make it more appropriate for the regional context:

- More emphasis on structured product development;
- Redesign focus instead of new product design;
- Benchmark approach added;
- Simplified tools;
- Focus on internal drivers because;
- Use of regional examples;
- In local language.

#### Structured product development

The original Western UNEP Ecodesign manual assumes that design theory is already known. In the European context, most companies starting with Ecodesign do have a structured product development system in place and many medium sized and large companies employ professional industrial design engineers. However, for many of the companies in developing countries applying Ecodesign is not only their first Ecodesign project, but also the also the first experience with formalized systematic product development (Crul and Diehl 1999; Diehl, Crul et al. 2001). Most SMEs in developing countries rely on a rather non-structured informal design process based on practical experience.

*In the D4S-DE manual as specific module has been added to introduce and explain the product development process.*

#### Redesign focus

The (European) UNEP Ecodesign manual (Brezet and Hemel 1997) already suggests starting with a redesign approach by choosing a reference product first. Still, much of the attention is given to new product development (new products, new markets). In the case of developing countries, most (SME) companies are at the beginning of that learning curve, and will start with redesign of their current products (Crul 2003). 'EcoRedesign' approaches match well with the general level of innovation (incremental) and product development know-how (limited) in the target group of small and medium sized companies in Developing Countries (Diehl, Crul et al. 2001).

*More strongly focused at redesign options and improvement directions, both in the practical projects and in the examples and tools presented in the manual.*

#### Benchmarking

The 'Redesign' process in most of the companies can be primarily seen as a benchmarking or copying type of innovation process. The improvement directions are derived from examples of competitors or comparable products from Europe or the United States (Crul 2003). Common strategies that are being followed for this are either a lower price strategy, usually competing with products that were imported, or an improved product quality strategy competing with other regional producers. Products of the competitors are observed in shops and fairs or are bought and (if applicable) dismantled. Pictures and description from the Internet or catalogues are used for identifying design improvements.

This means that the Ecodesign approach as used in Europe is probably too much focused on the innovation and redesign type of product development, while in developing countries there is much more need for (intelligent) copying approaches. 'Intelligent', because it should be remarked that some focus on innovative elements in product development, integrated into an overall copying approach, will be of great extra value to the companies.

*A step-by-step benchmark method has been formulated to benchmark competitors' or foreign products and process the information in such a way that constructive improvement options can be derived from it. A specific module 'D4S Benchmarking' has been added to the manual.*

#### Drivers

In the European context, external drivers play the main driving force for Design for Sustainability. Government policy, market demand, activities of competitors, demands from suppliers, pressure from the social environment (public opinion) all can push companies to start D4S. In most developing countries these external drivers for D4S are absent. Legislation is basically effect-oriented and certainly not focused towards environmental and social aspects of products. Existing environmental policy towards industry in general is not well established and not very strict implemented. Internal drivers are much more important for the companies – cost reduction, image, environmental benefit, competitiveness by better product quality and new markets.

This 'low urgency level' of external (environmental) drivers means, that when introducing D4S in developing countries, environmental and social arguments have to be coupled with internal drivers like cost reduction, market growth, image, competitiveness by better product quality arguments.

*The D4S-DE approach has been adapted in this respect. In the practical steps in the case studies, internal drivers are the key factor to be analysed. In the manual, the element of internal drivers is emphasized more clearly and analysis in cost reduction opportunities is given more priority.*

#### Simplified tools

The tools presented in the European UNEP Ecodesign approach are conceptually complex and require a lot of insight into both environmental & social problems and product development. This insight will be lacking in most SMEs. The use of the tools requires some skill in the use of abstract and 'integral' tools, in which many elements are interconnected. If people are not trained to look at a problem in this way, it is difficult to use. A combination with simplified checklist-type of tools is recommended for self-use in the companies.

*Therefore, a number of simplified tools were developed in several of the case studies, and tested in the companies. Usually, those tools included checklists, rules-of-thumb and questionnaires for the company to use.*

#### Use of regional examples

The European manual is illustrated with many examples of D4S worldwide – mainly of industrialized countries and the connected typical 'high-tech' sectors. For a manual for developing countries to be effective, it has to be illustrated with regional 'low-tech' examples. On the basis of the experiences with the company case studies, the D4S-DE manual includes mainly regional examples. This makes it easier for the companies that use the manual to relate to the topic, and also can convince them that D4S is actually working for their specific circumstances.

### 3. The UNEP D4S-DE manual

The Design for Sustainability (DfS) program of the Delft University of Technology (DUT) in collaboration with the United Nations Environment Program (UNEP) has launched a Design for Sustainability manual targeted at especially SMEs in Emerging and Developing Economies - D4S-DE (Crul and Diehl 2006). Based upon the experiences of DfS and UNEP with Design for Sustainability in universities and companies in, among others, East Africa, Central America and India an adapted manual and set of tools have been developed which fits into the context of small and medium sized enterprises in developing economies.

The manual is built up around 3 main parts:

1. What is D4S and why do it?,
2. How to do D4S in practice,
3. and reference information on D4S.

In addition there is a set of worksheets available for providing training to SMEs (see Figure 2).

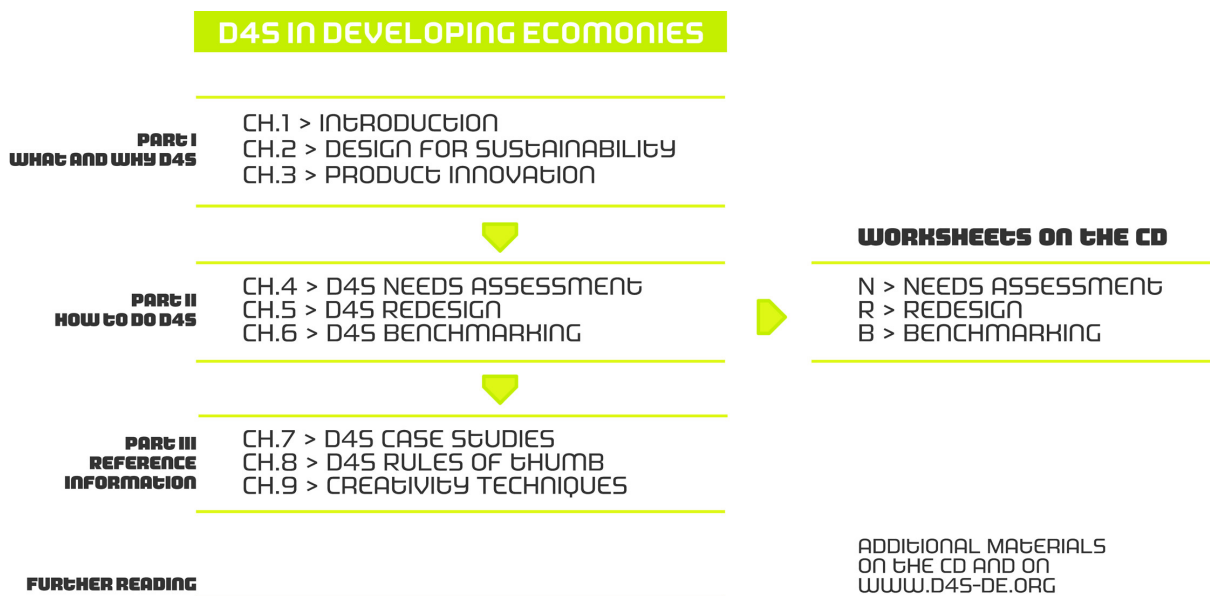


Figure 2: Structure and content of the Design for Sustainability manual for Developing Economies (D4S-DE)

The part on *How to do D4S in practice* is the backbone of the approach. It explains three practical, step-by-step approaches to execute a D4S project in a company. Successful D4S projects require good insight and understanding of the national economy and the possibilities with the local industry. Therefore, as a first approach, the D4S Needs Assessment shows how to evaluate the economic position of a country and how to prioritize industry sectors in order to target the selection of demonstration project companies. The needs assessment is intended for intermediaries who set up a D4S programme or project.

The next 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. D4S Redesign is of particular interest for developing economies because this incremental type of product innovation involves smaller risks and investment, follows a structured and predictable process and is known to be economically and commercially as important as more radical approaches such as development of completely new products. 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, investments costs would likely remain within reasonable boundaries. The risks connected with the redesign effort are lower compared to more radical D4S innovation strategies. The approach outlines a 10-step schedule to carry out a D4S Redesign project, each step reflecting a phase in the product development process.

Connected to the Redesign approach, the D4S Benchmarking approach is presented. It is especially suitable for those companies that develop products based upon imitating existing products. D4S Benchmarking is a structured approach to compare the environmental performance of a company's products against competitors' products and to generate improvement options. Since individual competitors often use different solutions to resolve the same design problems – like a different product architecture, components or technology – D4S Benchmarking offers a reflective approach and advises learning from others' products. Experience shows that, in practice, no single product scores high on all criteria and against all other products. This means that benchmarking improvement options can always be generated. An important element of benchmarking is the concept of best practice: 'those practices that please the customer most'. The goals of a benchmarking study should be based on customer needs, whether the customers are internal (departments within an organisation, higher management levels, or employees) or external (consumers, citizens, regulators, legislators, local and national environmental groups or investors). The redesign and benchmarking approaches are complementary to each other and can be used in combination.



Figure 3: The D4S-DE Web-site and manual

The manual has been tested with academic and business representatives from more than ten developing countries. The critics were very positive and as a result the D4S manual is currently being translated into Spanish, Portuguese and French. In addition the manual is currently being applied in Morocco, Costa Rica, East Africa, Vietnam and soon in Lao and Cambodia, in order to generate more local examples and showcases. Also several universities have picked up this initiative to develop their own Design for Sustainability courses.

The manual is free downloadable from the ([www.d4s-de.org](http://www.d4s-de.org)), which seems to be an appropriate mean in order to reach target groups all over the world with a limited budget (See Figure 3). The materials can be used by design schools all over the world to make a quick start to develop their own local Design for Sustainability courses. Translations in Spanish, Vietnamese and French are available.

#### 4. Case study

From the rich experiences with implementing D4S in developing countries, one example is given that show the opportunities of product innovation by SMEs.

Microplast is a plastic products company in Costa Rica with 70 employees producing different kinds of bottles for pharmaceutical, cosmetic and food products.

The product redesigned was a 1.8 litre HDPE bottle. In 2005, Microplast produced, on a small scale, a bottle of this size for milk and juices. The market for this type of bottle was increasing and the old bottle which had a lot of improvement potential, made it an interesting product for this project.

The redesign of the 1.8 litre HDPE bottle of Microplast was carried out in cooperation with a large Costa Rican food company. This company used 300,000 1.8 litre HDPE bottles per month. As a starting point for the redesign effort, the bottle from MicroPlast was compared to two bottles used by the leading competing company. The average weight of a bottle without a top was between 60 and 70 grams. The bottles were distributed in standard HDPE boxes. The boxes were also used for other types of packaging such as Tetra Pack and Tetra Brik. The company was able to put 12 bottles in one box.

The main environmentally focus areas were:

- Reduction of used material per bottle (D4S Strategy 2)
- Reduction of impact of packaging material per litre content (D4S Strategy 1 and 2)
- Reduction of waste material during production (D4S Strategy 3)
- Higher efficiency in distribution (D4S Strategy 5)

Next to the environmental focus areas, the following areas were also taken into account:

- Improve the ergonomic characteristics of the bottle
- Improve the aesthetics of the bottle

The wall thickness of the old bottle was approximately 0.6 mm. Benchmarking in The Netherlands proved that it was possible to reduce the thickness to 0.2 mm. This is only possible when the blowmolding machinery is equipped with a Parison Control system.

With such a system, a wall thickness for the new bottle of 0.3 mm was a feasible goal. New machinery and Parison Control would also reduce the amount of waste material during production.

To determine the dimensions of the new bottle, the dimensions of the distribution box were taken into account. With the dimension of the new bottle, it was possible to put 15 instead of 12 bottles in the distribution box resulting in an increase of 25%. With the computer program COSMOS, the mechanical characteristics of the bottle were examined. These stress analyses resulted in new positioning and number of rims. To improve the ergonomic aspects of the bottle, it was important to change the grip. The new grip was positioned in the middle of the bottle to avoid pain in the wrist during use. When the bottle is full (1.8 kilo), it is important that the momentum of the user is as small as possible.

To avoid pain to the hand, the grip was positioned in such way that the user could grasp the grip with all fingers and thumb. The ergonomic data used for the redesign of the grip was obtained via the Dynamic Anthropometrics Department of the Delft University of Technology.

**Results:**

- Material use reduction of 45-50%
- Better distribution efficiency of 25%
- Environmental impact reduction of 43%
- Better ergonomics
- Less reprocessing during production
- More attractive design



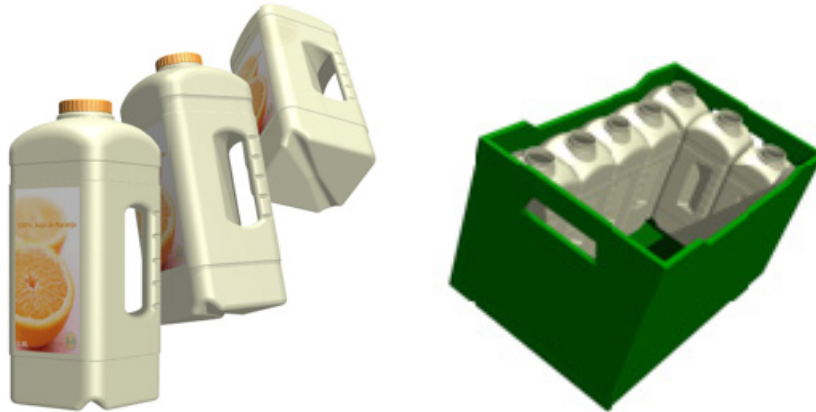


Figure 4: The D4S redesign results.

What does this mean in practice? On a scale of 300,000 bottles per month, this would mean a reduction of 9000 kilos of HDPE per month and thus a savings of 108 tons of HDPE per year. Furthermore, it was possible that the plastic packaging industry in Costa Rica would respond to the new thinner bottle of MicroPlast by developing new and better products. This could have a positive influence in the plastic packaging industry in Costa Rica. The two following examples illustrate the potential benefits in distribution. The first example was in the potential to reduce the cooling area. After the bottles are filled with juice or milk the bottles are stored in a cooled area to keep the quality of the content guaranteed.

The higher distribution efficiency means a reduction of 202.5 m<sup>3</sup> cooled storage area per month (based on 300 000 bottles per month). The second example was in the potential to reduce storage area in the cooled distribution trucks. A truckload contains 15 pallets. With 25% higher distribution efficiency, this means that 12 cooled truck journeys could be saved per month or 144 cooled truck trips per year. The economic and environmental benefits also include less gasoline consumption, maintenance costs and less labor costs.

## 5. Conclusions

Design for Sustainability (D4S) is a globally recognised way in which companies can work to improve efficiencies, product quality and market opportunities and at the same time increase environmental & social performance - resulting in a win-win situation. Most of the current available D4S manuals and tools have been developed in West Europe, based upon European experiences. However, in developing economies needs are different and more immediate. Also the characteristics of the local companies and product innovation approaches differ because of specific local social, economical and industrial development aspects. Till to date only a few targeted efforts have been made to develop a tailor made D4S approach specifically for the context of product innovation in Developing Economies.

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The manual has been tested with academic and business representatives from more than ten developing countries. The critics were very positive and as a result the D4S manual is used in several projects in China, India, Morocco, Costa Rica, Vietnam, Lao and Cambodia, and has been translated into Spanish, Vietnamese and French.

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