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DESIGN FOR SUSTAINABILITY

A Step-by-Step Approach

UNITED NATIONS ENVIRONMENT PROGRAMME
DELFT UNIVERSITY OF TECHNOLOGY

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FOREWORD

The United Nations Environment Programme Medium-Term Strategy 2010-2013 adopted by the Global Ministerial Environment Forum in February 2008, underlines that current economic growth and development patterns can not be sustained without a significant shift in global production and consumption trends. Decoupling economic growth from negative environmental and social impacts will require producers to rethink design, production and marketing paradigms. Consumers will need to consider real environmental and social concerns along a product's life cycle – in addition to price, convenience and quality, in their purchasing decisions. While these drastic changes face formidable challenges, there are encouraging developments contributing to an expanding knowledge base in the product development field. This publication is the most recent milestone in a series of steps towards more sustainable consumption and production. UNEP proudly supports this latest publication as an update of the successful 1997 manual, "Ecodesign: A Promising Approach to Sustainable Production and Consumption."

As a brief history, 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. These strategies also bolstered a company's position and competitive market edge where more and more emphasis was being placed on environmental stewardship. In 1997, UNEP published the ecodesign manual which was one of the first of its kind and helped lay the foundation for widespread adoption of ecodesign concepts by policy makers, programme officers, and project specialists. The manual was instrumental in inspiring other documents and sector specific publications on the topic.

Since then numerous initiatives and programmes have been carried out by industries and research institutions demonstrating how the economic, social and environmental benefits could be achieved through sustainable product design. UNEP working with the Technical University of Delft, led to the convening of leading sustainable product experts to outline the evolution of ecodesign to the concept of Design for Sustainability (D4S).

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. UNEP also supports related efforts operating in parallel that strive to achieve similar goals such as the Life Cycle Initiative and Eco-Labeling projects at the national level. Both activity areas seek to improve products by promoting supply chain responsibility and sustainable procurement to assess and manage the social and environmental impacts of products. The recent publication "Life Cycle Management: A business guide to sustainability" is an excellent overview on how to improve products by assessing and managing their impacts throughout their life cycle.

One of the largest challenges to more sustainable operations is a lack of communication about key initiatives, innovative strategies, effective solutions, and successful technical know-how. This publication is an example of one effort to address this limitation by presenting the collective insights of experts in the field. It covers D4S concepts ranging from incremental to radical innovation and provides an overview of D4S potential — why it works and who should be involved. The publication focuses specifically on four practical approaches, and provides a collection of case studies showing D4S applications and their sustainability benefits. Each chapter reflects the knowledge and lessons learned from a multitude of projects and represents years of logged project work. It is not meant to be a comprehensive or exhaustive review of D4S approaches but a presentation of the global picture and the key steps for application of the key areas of D4S intervention.

The publication targets designers and other professionals working in the area of industrial product development. It is useful to those new to ecodesign as well as those interested in breakthrough innovation for sustainability. This is also a sister publication to "Design for Sustainability: A Practical Approach for Developing Economies" (2006) which focused on the specific needs of small- and medium-sized companies in developing economies.

D4S GRAPHIC DESIGN CONCEPT

The D4S graphic design of this publication is based on the sustainability concept and its consideration of the three elements of PEOPLE, PROFIT AND PLANET. The graphic design is comprised of 3 subjects and 3 colours to illustrate these elements:

PEOPLE are illustrated by the expressions of Human beings from different cultures and races.

PLANET is represented by different natural elements of the planet such as water, rocks, trees, sand and plants.

PROFIT is illustrated by views of examples of highly developed sites from throughout the world.

The graphic design was developed by SUSDESIGN, an entity devoted to the promotion of Design for Sustainability and is illustrated with images from student projects and SUSDESIGN.

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D4S
DESIGN FOR SUSTAINABILITY

PART I

WHAT IS D4S AND WHY DO IT?

PART II

HOW TO DO D4S IN PRACTICE

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(ON THE WEB WWW.D4S-SBS.ORG)

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PART IV

(ON THE WEB WWW.D4S-SBS.ORG)

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Module B_ Design-Oriented Scenarios
Module C_ Product-Service Systems tools
Module D_ Creativity Techniques
Module E_ D4S Rules of Thumb

> Management Tools

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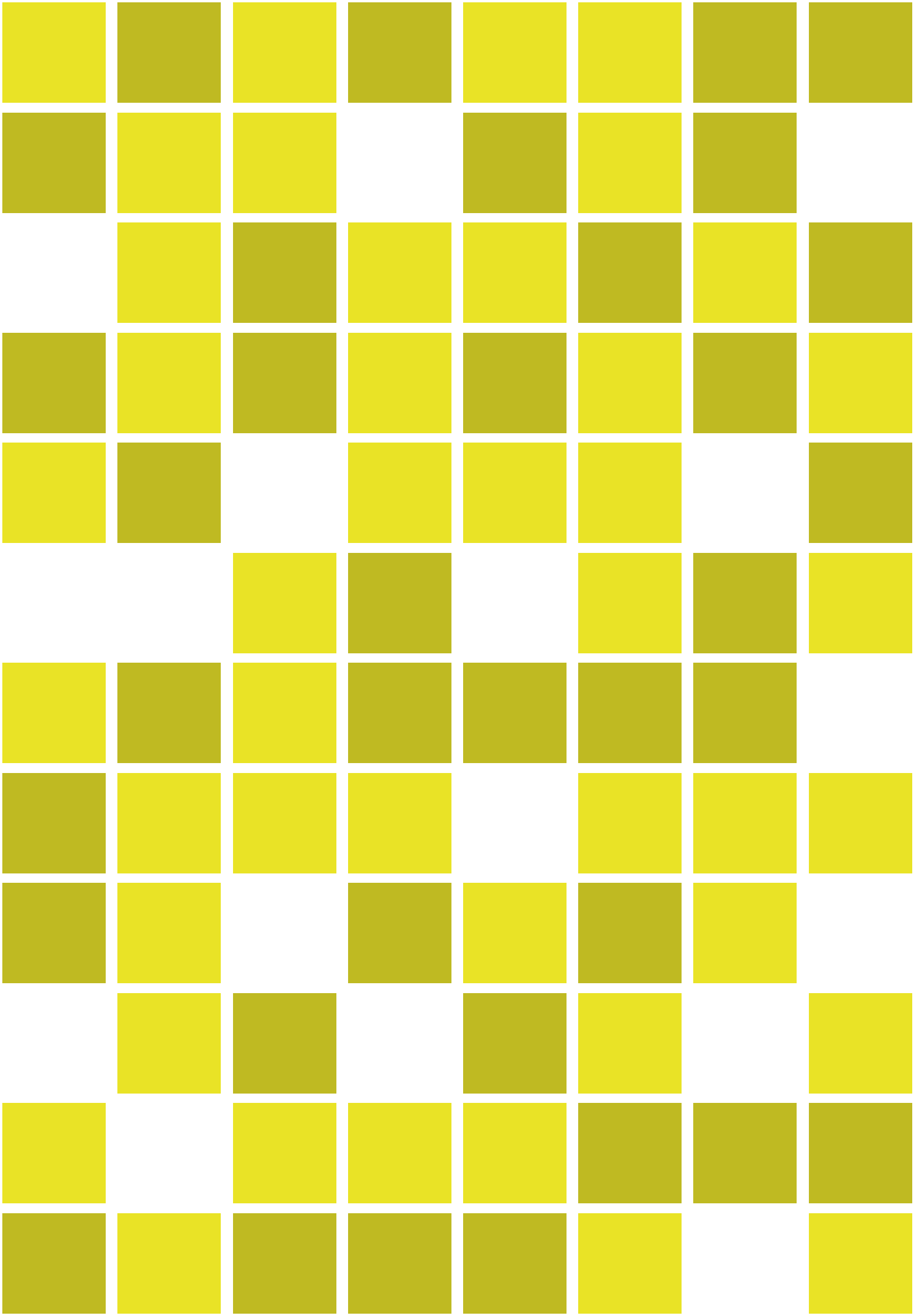
> Innovation Topics:

Module H_ Eco-Materials
Module I_ Energy
Module J_ ICT

> Worksheets

D4S Redesign
D4S Benchmarking
Product-Service Systems



PEOPLE

PART I

WHAT IS D4S AND WHY DO IT

001 INTRODUCTION TO THE D4S: A STEP-BY-STEP APPROACH

1.1 FROM ECODESIGN TO 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. These strategies also served to bolster a company's position and competitive edge in a market where more and more emphasis was being placed on environmental stewardship. In 1997, UNEP published "Ecodesign: A Promising Approach to Sustainable Production and Consumption" which was one of the first manuals of its kind and helped lay the foundation for widespread adoption of Ecodesign concepts. This publication introduced the fundamental concepts of Ecodesign to policy makers, programme officers, and project specialists. The manual has been instrumental in the development of many other documents and sector specific publications on the topic.

In the last ten years, the global threats of climate change have pushed environmental concerns to the forefront of political agendas around the world. In response to these concerns, many nations have taken up the urgent call to 'act now.' These countries have established policies designed to mitigate the deleterious effects of climate change by reducing greenhouse gas emissions, shifting energy supply to include a larger portion of renewable energy resources, and increasing energy efficiency.

While much emphasis is currently placed on climate change, other environmental issues and concerns are looming on the horizon. These include the availability of potable fresh water, increased deforestation, reduced biodiversity and the destruction of ecosystems. Reversing these trends requires dramatic changes in consumption and production at the process, product, service, and system levels.

Profound changes have taken place in the world economy and industrial production practices over the past decade. The accelerating processes of globalisation and trade liberalisation, supported by advances in information technologies, have fundamentally changed the landscape of the private sector in all countries. These changes have resulted in economies around the world becoming increasingly interconnected with developing economies playing a more and more important role in economic growth (i.e. China, India, Mexico, Brazil and Russia). In the wake of globalisation, it is becoming increasingly evident that current economic growth and development patterns cannot be sustained without significant innovation in both the supply (production) and demand (consumption) sides of the market. Therefore, there is a growing demand for companies to research and implement more innovative processes and develop better products and services. Governments can support this by providing a conducive policy environment and creating civil society programmes that facilitate the dis-

semination of information to promote the selection of sustainable products among consumers.

To keep pace with the rapidly changing industrial setting, many environmental movements have expanded their scope to include social and economic concerns. This combination of environmental, social, and economic priorities is referred to as 'sustainability.' Like many other environmental concepts, Ecodesign has evolved to include both the social and profit elements of production and is now referred to as sustainable product design. The concept of 'Design for Sustainability' (D4S) requires that the design process and resulting product take into account not only environmental concerns but social and economic concerns as well. The D4S criteria are referred to as the three pillars of sustainability - people, profit and planet. 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.

This step-by-step approach to D4S provides companies and intermediate organisations in developed and developing economies with practical support for both incremental and radical product innovation. It should be noted that by no means has incremental redesign or greening of products lost its relevance in today's marketplace. D4S essentially builds on these concepts and aims to drastically improve the efficiency and social qualities of production processes by developing new products, services, and systems. This publication provides examples and approaches on how to accomplish these goals.

The D4S: A Step-by-Step Approach was compiled by Delft University of Technology's Design for Sustainability (DfS) Programme for UNEP's Sustainable Consumption and Production Branch of the Division of Technology, Industry and Economics. Both organisations have been active in the area of promoting more sustainable product design since the introduction of these concepts in the 1990s. The publication is a result of a long-term cooperation with international experts from the Netherlands, Sweden, Italy, France, Germany, Japan, Australia, UNIDO, the Swedish EPA, InWent Germany, and UNEP and reflects the evolution of the concept.

UNEP supports a variety of D4S efforts — strengthening resource efficiency and sustainable consumption and production is a UNEP priority area. UNEP does this through strengthening the knowledge base underlying action by government, industry, and consumers, building governmental capacity to implement policies and tools, and strengthening partnerships with business and industry. These include initiatives such as reporting on economics and development implications of resource depletion, establishing supply chain partnerships with SMEs to enable them to meet more stringent environmental standards, or training key stakeholders on resource efficiency and sustainable consumption and production. In the D4S area, UNEP has developed materials to help business leaders, product designers, and policy makers rethink how to design and produce products to improve profits, competitiveness, and social benefits while reducing environmental impacts. In addition to the Ecodesign Manual (1997), other publications and tools include: *Design for Sustainability: A Practical Approach for Developing Economies (2006) (*developed in conjunction with Delft University of Technology, it introduces the D4S concept and methods for applying it in a business setting in developing economies). Relevant examples and case studies are included from demonstration projects carried out in Costa Rica and Morocco. It is available in English, French, Spanish, and Vietnamese. Other manuals cover life-cycle management*: Life-Cycle Management: A Business Guide to Sustainability (2007).* UNEP's work with UNIDO on the National Cleaner Production Centres (NCPC) Programme also highlights D4S as a focal area. For example, in 2008-9, UNEP is working with the Vietnamese NCPC to implement an EC supported project to test the D4S methodology. Disseminating the D4S concept globally is a long-term strategic focal area.

UNEP has an increased focus on design issues in sustainability efforts as a result of years of work in cleaner production and eco-efficient systems. The horizons of pollution prevention have widened from a focus on cleaner production processes to the broader concept of sustainable product design, and have expanded to include transport logistics, end-of-life collection, and component reuse or materials recycling. These product systems innovations in existing endeavors couple well with new products, systems, and enterprises designed to create win-win solutions for businesses, local com-

munities, supply chains, the environment, and consumers. Each product or system that is designed with resource efficiency and a full life-cycle analysis in mind contributes to the promotion of a 10 Year Framework of Programmes on Sustainable Consumption and Production patterns that was mandated at the World Summit on Sustainable Development in 2002. (http://www.unep.fr/scp/design/d4s.htm)

Delft University of Technology's D4S Programme has extensive experience in sustainable product, service, and system innovation worldwide. Industrial and research projects are carried out in the areas of products, renewable energy, innovative mobility, renewable materials, sustainable Product-Service Systems, telemedicine, leisure products, and regional innovation. Projects have been executed in the Netherlands, Europe, Africa, Asia, and Latin America. Several of the corporate projects are used as examples and case studies in the publication.

1.2 TO WHOM IS THIS PUBLICATION ADDRESSED?

This publication is written for professionals involved in product innovation and sustainability, including innovators, product developers, company executive managers, environmental managers, intermediates such as consultants, centres of excellence, and researchers. It is also relevant for professionals from business associations, NGOs, and governments that work with industry in joint projects. The type of D4S related methodologies proposed in this publication can be used in a collaborative process with several partners, either within a company, or within a project where intermediates and companies are involved. Certain chapters of this publication were written to be used by an in-company or external project team that can initiate D4S projects (i.e. the quick-start, and the redesign and benchmarking chapters). Other chapters outline concepts or initiatives that require a broader partnership of companies and societal actors, or a longer timeline for the execution of the project (i.e. the product innovation, product-service systems and system innovation chapters).

This publication is addressed to professionals in both developed and developing countries. It presents the concept, its rationale and context, and approaches to apply D4S. A separate publication on D4S in developing economies (D4S-DE) was published by UNEP in 2006. Given their unique and more immediate needs, particularly in the area of awareness and capacity building, the D4S-DE publication focused on needs assessment, redesign, and benchmarking of products and outlined a practical approach that is feasible for the context.

However, this does not exclude the importance of 'leapfrogging' towards new and more sustainable products, services, and systems which are presented in this step-by-step approach. As redesign and benchmarking can be highly valuable approaches in developed economies as well, text on product redesign and innovation is provided in Chapters 4 and 5, respectively. Information on benchmarking is detailed in Module A, and the worksheets on redesign and benchmarking on the web, are all similar to what has been presented in the D4S-DE publication.

1.3 HOW TO READ THIS PUBLICATION

This publication is comprised of four parts (Parts I-IV) - two are contained in this document (Parts I-II). Parts III and IV are a series of modules that are located on the webpage www.d4s-sbs.org <http://d4s-sbs.org>. Readers can navigate this publication in different ways depending on their interests and focuses. Reading suggestions are provided below.

In Part I, **What is D4S and why do it?** (Chapters 1 – 2), introduces the concepts and motivations for D4S initiatives. Chapter 2 provides an overview of the relationship between sustainability and product innovation and how to meet consumer needs while improving the environmental, social, and economical aspects of products. Chapter 2 also outlines the basic concept of product innovation and the difference between incremental and radical innovation. The three approaches featured in this publication – redesign, new product development and Product-Service Systems (PSS) – and their common basic steps (policy formulation – idea generation – strict development – realisation) are introduced. For each of the methods, these four steps are subdivided differently (see Figure 1-1), based on specific goals and requirements. As a final part of this chapter, the reasons for a

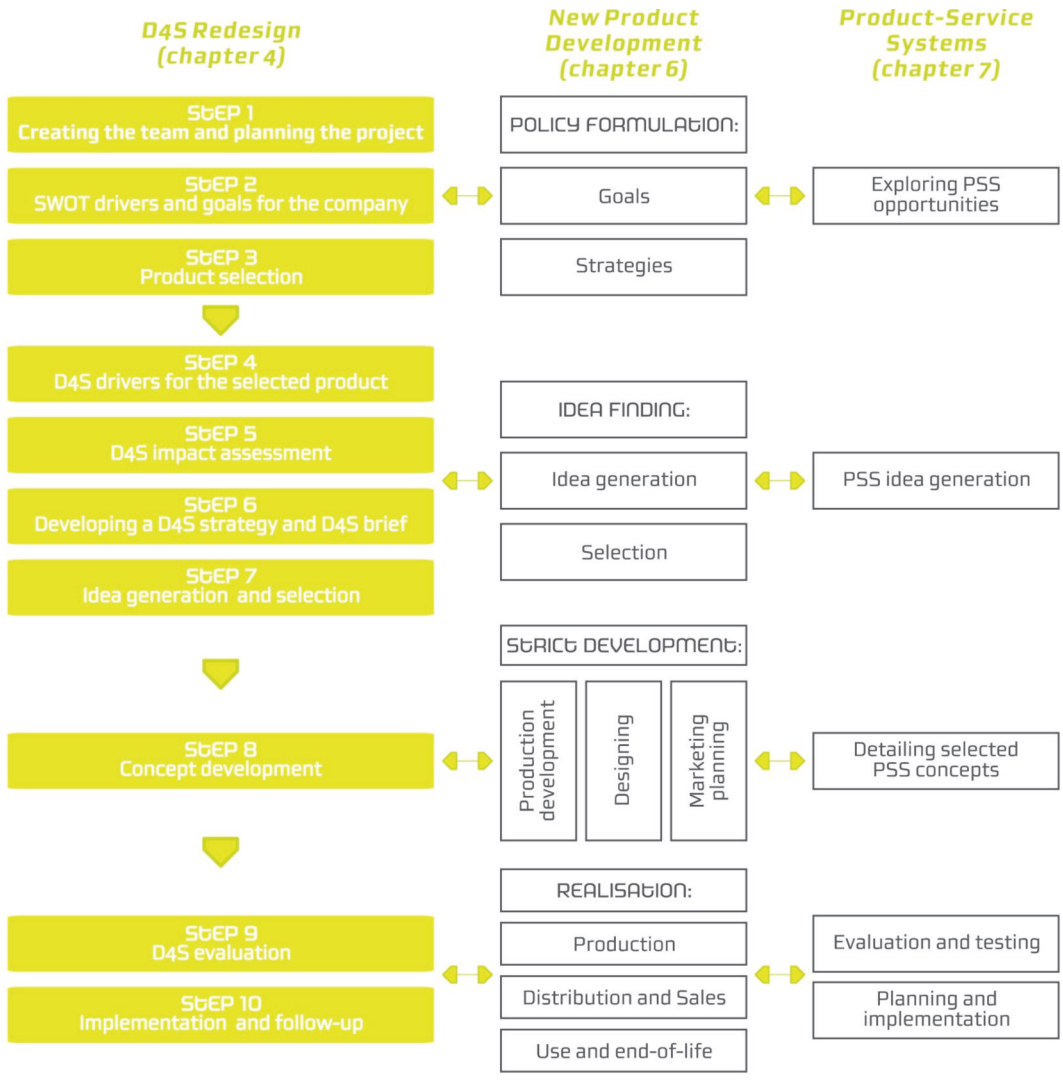


FIGURE 1-1: STEPWISE APPROACHES FOR REDESIGN, NEW PRODUCT DEVELOPMENT AND PSS.

company to work on sustainable solutions are discussed.

Part II, **How to do D4S** (Chapters 3 – 7), is the publication's core. This portion of the document outlines the practical design approaches to execute a D4S project in a company or network: Redesign, new product development and PSS development. Additional methods and tools are provided in modules on the web.

Chapter 3 is the Quick Start approach for D4S. This chapter aims to orientate readers on the D4S process and provides guidance on selecting from the various types of D4S approaches.

Chapter 4 describes the key incremental innovation strategy: *D4S Redesign*. This strategy is aimed at sustainability-driven, incremental improvement of an existing product. A closely connected approach, *D4S Benchmarking*, is presented in Module A on the web. This benchmarking approach 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 prod-

ucts. A comprehensive set of worksheets on redesign and benchmarking is included on the web.

Chapter 5 emphasises the importance of out-of-the-box or radical sustainable product innovation. It describes how to efficiently and effectively manage radical innovation and reduce risk.

Chapter 6 highlights new product development and shows similarities and dissimilarities with redesign. This chapter also provides examples of several innovative new product technologies, three of which are detailed in the innovation topic annexes on the web: application of new eco-materials (Module H), integration of new energy systems in products (Module I), and application of ICT technologies (Module J). Innovative new products often are part of system innovations on both the technical and socio-cultural level.

Chapter 7 details Product-Service Systems (PSS). This design approach was developed to accommodate the fact that services and products are becoming increasingly intertwined, and if properly designed and managed, can fulfill customer's needs more efficiently and sustainably than purely product based solutions. A step-by-step approach for a PSS pilot project is provided, and this methodology is further detailed in Module C on the web. Module B on the web also provides information and examples on design-oriented scenario building, which is closely connected to PSS.

The conclusion of this section provides suggestions for further reading.

Part III of the publication consists of **Case Studies** on the web. provides five case studies that depict the concepts outlined in the previous chapters (drivers, Redesign, radical innovation, new product development and PSS). Each case begins by listing the company and stakeholders implementing the D4S initiative, the issue, the goals and process of the case, and finally the project results.

Part IV of this publication consists of the supporting materials on the web. These resources are grouped into the following categories: **design tools, management tools, design related innovation topics, and three sets of worksheets.** The design tools are to be applied in combination with the methodologies described in Part II of this publication. The contents of Modules A, B, and C have already been presented. Module D provides an overview of creative techniques a D4S team can apply in developing novel solutions to product innovation challenges. Module E includes rules of thumb for implementing D4S projects. Management tools (Module F) and communication tools (Module G) are presented to assist professionals initiating D4S projects, as well as those responsible for internal and external communication.

Modules on innovation topics - eco-materials (Module H), energy (Module I), and ICT (Module J) - have already been presented in connection with Chapter 6 on new product development. Finally, three sets of worksheets on Redesign, PSS, and benchmarking are provided to better assist individuals targeting these efforts. The web also holds a printer-friendly version of the entire publication. The website with the same digital information and additional materials can be found at: http://www.d4s-sbs.org

An overview of the publication which highlights the relationship between the various Chapters and Modules is provided in Figure 1-2.

The following selections are recommended for fast track reading:

FAST TRACK READING SUGGESTIONS:

I do not have an idea yet: Read Chapter 2: What is D4S and Why Do It? and Chapter 3: A 'Quick Start' approach to D4S. Browse through rest of the publication. After that, decide what you want to do and see below.

I want to redesign existing products: Read Chapter 2: What is D4S and Why Do It? Chapter 3: A 'Quick Start' approach to D4S, Chapter 4: Inside-the-box: D4S Redesign, Module A on benchmarking, Modules D and E on creativity and rules of thumb, and Modules F and G on management and communication for reference. Use Redesign/benchmarking worksheets as needed.

I want to develop new products: Read Chapter 2: What is D4S and Why Do It? and Chapter 3: A 'Quick Start' approach to D4S, Chapter 5: Outside-of-the-Box: Radical Innovation Sustainable Product Innovation, Chapter 6: New Product Development, Modules D and E on creativity and rules of thumb and Modules H, I, and J on innovation topics. See Modules F and G for reference.

I want to develop Product-Service Systems: Read Chapter 2: What is D4S and Why Do It? Chapter 5: Outside-of-the-Box: Radical Innovation Sustainable Product Innovation, Chapter 7: Product-Service Systems, Modules B and C on design-oriented scenarios and PSS tools, Modules F and G for reference. Use PSS

PUBLICATION OVERVIEW

D4S A STEP-BY-STEP APPROACH

In the book

1 > INTRODUCTION

2 > WHAT IS D4S AND WHY DO IT

3 > 'QUICK START' APPROACH

4> IN-THE-BOX: D4S REDESIGN

5> OUT-OF-THE-BOX: RADICAL D4S

6> NEW PRODUCT DEVELOPMENT

7> PRODUCT-SERVICE SYSTEMS

MODULE A

MODULE H I J

MODULE B C

On WWW.D4S-SBS.ORG <HTTP://WWW.D4S-SBS.ORG>

8> D4S CASE STUDIES

DESIGN TOOLS

A. Benchmarking
B. Design-Oriented Scenarios
C. Product-Service System tools
D. Creativity Techniques
E. D4S Rules of Thumb

MANAGMENT TOOLS

F. D4S Management
G. D4S Communication

Worksheets_
Redesign
Benchmarking
Product-Services

INNOVATION TOPICS

H. Eco-material
I. Energy
J. ICT

FIGURE 1-2 ___ PUBLICATION OVERVIEW

002 WHAT IS D4S AND WHY DO IT

MARCEL CRUL, JAN CAREL DIEHL AND THOMAS LINDQVIST

Design for Sustainability (D4S) is a key tool in incorporating sustainability concepts into the design and product innovation processes that companies employ. The role of the environmental, social, and economic aspects of sustainability as they relate to product innovation is explored in this chapter. The key drivers for D4S and a basic scheme for product development will also be presented.

2.1 PRODUCTS AND SUSTAINABILITY

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 globalisation and trade liberalisation, supported by 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. Large and small companies have made impressive efforts to address sustainability issues with a bottom line focus. Companies are improving the efficiency of current production and the design of new products and services through supply chain management, corporate reporting, benchmarking, and adopting related international standards.

These profit-driven strategies go by many names, such as sustainable product design and Design for Sustainability (D4S). D4S, which includes the more limited concept of Ecodesign (Chapter 1 describes the evolution of Ecodesign to D4S), is one globally recognised way that companies can improve efficiencies, product quality, and market opportunities while simultaneously improving environmental performance, social impacts, and profit margins. Many developed economies are highly aware of the business opportunities related to efficiency increases and more stringent environmental and social standards. D4S efforts have already been linked to wider concepts such as product-service mixes, systems innovation and other life-cycle-based efforts. In developing economies, more immediate technical support is needed to introduce the D4S concept.

Many organisations have developed tools to help companies, designers, and consultants rethink how to design and produce products in a way that improves profits and competitiveness while reducing adverse environmental impacts. Over time, this process, known as Ecodesign, has evolved to encompass broader issues such as the social component of sustainability and the need to develop less resources intensive ways to meet consumer needs. D4S goes beyond how to make a 'green' product and addresses how to best meet consumer needs on a social, economic, and environmental level. This does not only include the individual product, but also the system of products and related services which are jointly capable of fulfilling consumer needs more efficiently and with a higher value for both companies and consumers.

The 3 key elements of sustainability – social, environmental, and economic – are also referred to as *people*, *planet*, and *profit*, and are the fundamental components of product innovation (see Figure 2-1).

To be sustainable, product innovation must work within a number of frameworks linked to people, planet, and profit, including social expectations, equitable distribution of value along the global value chain, and the carrying capacity of the supporting ecosystems. Examples of sustainability challenges include:

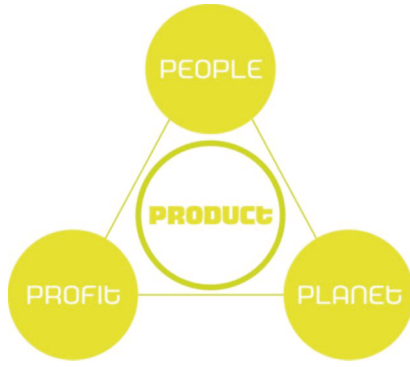


FIGURE 2-1 ___ PEOPLE, PROFIT, PLANET AND PRODUCT

PEOPLE: CREATE OPPORTUNITIES TO MEET SOCIAL AND EQUITY REQUIREMENTS

> Reduce urban and minority unemployment
> Improve working conditions, safety, and well-being
> Acceptance and integration of minorities
> Reduce income inequity
> Enhance number of skilled workers
> Abolish child labour
> Reduce illiteracy
> Provide basic health services
> Provide clean drinking water
> Reduce population growth
> Improve status of women
> Adopt international employment standards
> Increase social opportunities and community interaction
> Abolish large scale dislocation of people

PLANET: FIT WITHIN THE CARRYING CAPACITY OF SUPPORTING ECOSYSTEMS

> Reduce fossil fuel energy use
> Use of renewable energy
> Increase energy efficiency
> Reduce use of toxics
> Clean contaminated sites
> Improve level of waste prevention, recycling, and reuse
> Reduce and treat industrial emissions
> Reduce quantity of waste water and promote treatment
> Stop overexploitation of renewable resources and water
> Stop deforestation, soil loss, erosion, and ecosystem destruction
> Reduce dung and wood burning

PROFIT: CREATE EQUITABLE VALUE FOR CUSTOMERS AND STAKEHOLDERS ALONG THE GLOBAL VALUE CHAIN

> Value for company and stakeholders
> Value for customers
> Fair business model
> Fair share of and linkage to global value chains
> Linkage of small and medium sized enterprises in developing countries to large transnational companies
> Fair price for commodities and raw materials
> Ownership and credit opportunities for entrepreneurs

The company capacity to undertake D4S initiatives is highly variable from one organisation to the next. If organisations with lower D4S capacity levels were expected to integrate every element outlined above, many product innovation ideas would not be implemented. Furthermore, the afore mentioned elements may not be relevant to all companies and countries. To facilitate the D4S process and maximise project impact, companies should review their sectoral needs to identify the design aspects that would yield maximum positive impacts and the successful achievement of goals and targeted elements of D4S projects.

A carefully prepared D4S project can have a significant impact on a company's future competitiveness, as well as immediate benefits. Sustainability requirements are increasingly being incorporated into corporate supply chain requirements, government procurement guidelines, and consumer decision making.

During the development of a new product, or the redesign of an existing one, the product development team is confronted with a variety of design criteria such as quality, ergonomics, safety, and aesthetics. When using the D4S approach, environmental, social, and profit criteria are integrated into the product development process along with elements that serve to minimise the adverse impacts of the product throughout its life-cycle.

2.2 PRODUCTS AND ENVIRONMENTAL ASPECTS – PLANET IMPLICATIONS

In the late 1980s and early 1990s, sustainability was largely an environmental issue. Initially efforts focused on improving end-of-pipe technologies, designed to treat waste and polluting streams. In the mid-1990s, the focus 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 to address the environmental concerns associated with production and consumption processes. D4S is the latest evolution of product design and takes into account the overarching goals of sustainability, which include social and economic concerns.

Environmental impacts can be divided into three main categories: ecological damage, human health damage and resource depletion (see Table 2-1). These impacts, including eutrophication, land use, ecotoxicity, human health damage, and the depletion of fossil fuels and fresh water, are relevant to large industries and SMEs in both developed and developing economies.

Another way to classify the different types of environmental impacts is by geographical scale– local, regional, fluvial, continental, or global. Typically, the higher the scale level, the more sources that contribute to the impact, the greater the need for international collaboration to solve issues, and the longer it takes for improvements to become visible – depending on the reversibility of the problem. A legal framework is in place for many industrialised countries to enforce regulations that deal with local problems like water pollution, soil pollution, and waste disposal, however, while developing economies may posses a similar legal framework, they may lack the enforcement capacity necessary to successfully address these issues. Global issues like climate change are best tackled through international cooperative global warming mitigation efforts. Irreversible depletion problems, even when occurring locally, such as loss of topsoil, are not easily solved, therefore preventive steps to avoid depletion are the most cost-effective. After preventative solutions, back-

TYPE OF IMPACT	DESCRIPTION
1_ ECOLOGICAL DAMAGE	
Global warming or climate change	Addition of greenhouse gases to the atmosphere from burning of fossil fuels, agriculture, industrial practices. Effects: temperature change, increased incidence of storms, desertification, tropical disease, ocean current changes, sea level rise.
Ozone depletion	Stratospheric ozone depletion caused by emissions of CFCs. Effects: increased amount of UV radiation leading to increased cancer occurrence, reduced productivity of plants, marine algae and high altitude biota.
Acid rain	Acidification of precipitation by emission of sulphuric and other substances, mainly from fossil fuels. Effects: dissolves metals from the soil which become toxic to plants and aquatic organisms.
Water eutrophication	Addition of excess nutrients to water, leading to algae bloom and consequent reduction of available oxygen. Effects: killing of fish and other aquatic organism.
Habitat alteration (land use)	Physical modification or destruction of natural habitats for agriculture, forestry, roads and urban growth. Effects: Primary cause of loss of biodiversity.
Ecotoxicity	Exposure of plants, animals and other biota to toxic substances. Wide range of effects.
2_ HUMAN HEALTH DAMAGE	
Smog and air pollution	Emission of nitrogen oxides and VOCs generates ground level ozone, other air pollutants include dust particles and sulphur dioxide. Effects in humans: increased incidence of asthma and other health disorders.
Health damaging substances	Non-cancer causing substances include skin irritants, growth inhibitors, endocrine disruptors.
Carcinogens	Cancer causing substances, mutagens that cause genetic mutation (most of them are also carcinogenic), teratogens cause defects in developing embryos.
3_RESOURCE DEPLETION	
Fossil fuels	Current consumption rates of oil, gas, coal convert fuels into materials, energy and CO2 at a rate millions of times faster then nature can replenish the fuel reservoirs.
Fresh water	Consumption of fresh surface or groundwater converts theminto forms that are typically nonrecoverable. Access to clean, potable water is a fast growing international problem.
Minerals	Metal ores are cnverted into metals and alloys that are eventually oxidized or dispersed as waste that is often not recycled.
Topsoil	In many places, agriculture and forestry erodes topsoil at a rate much faster then natural processes replenish it.

TABLE 2-1 ___ ECOLOGICAL IMPACT CATEGORIES

stopping technologies like CO2 sequestration and toxic waste incineration will remain necessary to tackle problems on all scales.

2.3 PRODUCTS AND SOCIAL ASPECTS – PEOPLE IMPLICATIONS

Social aspects of sustainability have begun to receive more attention from the media over the last 10 years as exemplified by negative articles on child labour, companies running 'sweatshops', workers' rights and indigenous peoples. Corporate strategies increasingly include corporate social responsibility in addition to economic and environmental priorities. These social concerns are relevant to all stakeholders, including investors, participants in a supply chain, and local communities.

Products and the production process impact people in a variety of ways. Understanding the vast spectrum of societal aspects relevant to sustainable production better equips companies to assess impacts and design and/or modify existing product designs to enhance the positive societal impacts and decrease the negative. Table 2-2 outlines societal aspects of sustainable production and potential impacts. Societal impacts can include on-the-job injuries, consumer and employee health effects to chemical exposure, exploitation of labour, child labour, and resource conflict (diminishing water and food supplies).

2.4 PRODUCTS AND FINANCIAL ASPECTS – PROFIT IMPLICATIONS

In addition to environmental and social benefits, D4S can also help a company's bottom line. Sustainability improvements made to products can lower production costs through increased resource efficiency, open up new markets and improve the quality of the product produced, increase customer loyalty and marketing opportunities, and link smaller companies to global value chains and multinational companies.

D4S improvements often involve the improvement of resource efficiency during production and an overall

SUPPLY CHAIN	
Human Rights	Protection of employees' basic rights, such as freedom of speech, right to fair wages, and absence of discrimination.
Child Labour	Elimination of the economic exploitation of children, which interferes with their education, health, and physical, mental, spiritual, moral, or social development.
Workplace Health & Safety	A high-quality work environment that protects the health and safety of employees and promotes workplace diversity, vocational education, and quality work-life balance.
Governance & Management	Systems and processes which govern accountability, transparency, responsibilities of various stakeholders. Can also include documentation, reporting, strategy, and risk management.
Transparency	The degree to which a company involves its business partners in carrying out its sustainability strategy, and publishes information on its practices and behaviour in an accessible format.
Corruption & Bribery	A stable, ethical, and transparent economic environment that facilitates the mobility of investment, finance, and technology.
LOCAL AND SOCIETAL IMPACTS	
Economic Growth	Sharing the benefits of an investment and the tools for economic growth with local businesses and community members.
Community Development	Facilitation of the development of health, education, water and sanitation resources in a community, as well as supporting local efforts to eradicate corruption and human rights violations.
Stakeholder Engagement	Consulting with non-business stakeholders on key sustainability issues, possibly in the form of open dialogue with societal partners (NGOs, government, community groups).
Distributed Economies (DE)	Distribution of a selected share of production to regions which support small scale, flexible units that are connected with each other and prioritise quality production.
SOCIETAL IMPACTS	
Saline Encroachment	Overtaxing groundwater resources in coastal areas can cause saltwater intrusion whereby the over withdrawal of potable groundwater resources pulls saline water into freshwater areas which can contaminate drinking water supplies.
Land Subsidence	Over withdrawals from certain aquifer lithologies reduces the pore water pressure, increasing the effective stress which leads to the irreversible subsidence or sinking of the land surface. Societal impacts include reduced groundwater resource capacity and cracking building foundations.

TABLE 2-2 ___ SOCIAL IMPACT ASPECTS

reduction in material and energy used. More resource efficient production can contribute to significant material savings for companies through reduced material use, reduced energy consumption, and increased recycling. Additionally, reduced material and energy requirements can insulate profit margins from volatile energy and commodity markets.

The greening of products can open up new markets that have previously been out of reach due to regulatory requirements or consumer preferences, and allay consumer fears over contaminated products. Sales can also be increased through expanding marketing opportunities and strengthened customer loyalty. A company's market position can be reinforced and enhanced via links to global value chains and multinational companies brought about by D4S initiatives.

2.5 LIFE-CYCLE AND IMPROVEMENT FACTOR THINKING

2.5.1 LIFE-CYCLE

The D4S approach is based on taking the entire life-cycle of a product into consideration when evaluating sustainability impacts (See Figure 2-2). The product life-cycle starts with the extraction, processing and supply of the raw materials and energy needed for the product. It then covers the production of the product, its distribution, use (and possibly reuse and recycling), and its ultimate disposal. A variety of environmental and social impacts occur in different phases of the product life-cycle and should be accounted for in an integrated way. Key environmental factors are the consumption of input materials (water, non-renewable resources, and energy in each of the life-cycle stages) and production of output materials (solid and chemical waste, wastewater, heat, and emissions) and factors like noise, vibration, radiation, and electromagnetic fields. Key social factors are labour policies, production processes that use toxic chemicals to generate products that can adversely affect workers and consumers, and unsustainable consumption of natural materials that ultimately adversely impacts ecosystems and biodiversity in local communities. An example of a product life-cycle evaluation is provided in Box 2-1.

FIGURE 2-2 ___ THE LIFE CYCLE OF A PRODUCT

Though they are the subject of much environmental focus, raw material provision and factory production are only two stages of the product life-cycle. In many cases, the distribution, use and disposal phases have higher environmental than the production itself. The environmental and challenge for D4S is to design products that minimise environmental and impacts during the entire product life-cycle, not just during production.

Various parts of the value chain connected to a product's material life-cycle should also be considered to fully address social concerns. Social issues in each phase must also be addressed. Specifically, social concerns can arise around child labour, employee wages, and equal opportunities in the production phase with relation to the employees.

As a product reaches a consumer, compliance, health, and safety issues also highlight the social impacts.

In many cases, the added value generated during different steps of the life-cycle varies considerably; it is often relatively low in the extraction and production steps and higher in the sales and service steps.

BOX 2-1: THE LIFE-CYCLE OF A SHIRT

Shirts are often a combination of natural and synthetic fibers. To produce natural fibers (e.g., cotton), energy, fertilisers, water, and pesticides are needed. For synthetic fibers, chemicals, water, and energy for extensive manufacturing are required. These fibers are combined into cloth during a process

which uses water, energy, and chemicals to give cloth its colour and other characteristics. From the cloth, shirts are produced and then packaged and distributed to retail shops. After the consumer has purchased the shirt, he or she will discard the packaging and will use the shirt. During the use phase, the shirt, on average, will be worn 100 times, washed, dried and maybe even ironed. Each of these steps has environmental impacts resulting from detergent, water, and energy use. Finally, perhaps when some parts of the shirt have worn out, it will be discarded. It is not possible to compost it because of the synthetic parts, and it may not be easy to recycle because of the mixed materials. During its life time, components of the shirt may have traveled thousands of kilometers, since the production of the cloth production could have occurred in Asia, the manufacturing of the shirt in North Africa, and the retail in Europe. There are also social implications within this life-cycle. Social aspects could include the working conditions on cotton plantations, as well as in the production facilities where cotton and other synthetic fibers are developed into usable materials, and finally the factories where the garments are manufactured. The labour policies used throughout this process can have adverse social impacts (one such example is sweatshops employing child labour). When evaluating and seeking to improve social impacts throughout the life-cycle, efforts should be made to promote a better distribution of benefits throughout the value chain.

2.5.2 IMPROVEMENT FACTORS

Sustainability also 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 rates 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' shows the magnitude of the task at hand, and the critical need to improve production processes, products, and systems. Short-term incremental redesign of existing products, also called 'inside-the-box' innovation, can typically lead to improvements of a factor of 2 to 4. To achieve long-term factors of 10 to 20, 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. Figure 2-3 illustrates the different degrees of environmental benefit and innovation required.

In the next section, the different types of innovation are explained in more detail.

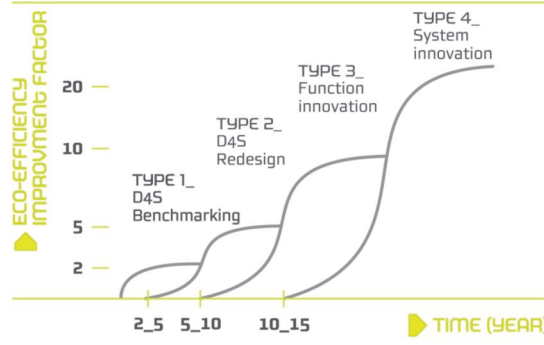


FIGURE 2-3 ___ DEGREES OF ENVIRONMENTAL BENEFIT AND TYPE OF INNOVATION REQUIRED

2.6 PRODUCT INNOVATION

Since D4S is based on a combination of product innovation and sustainability, understanding the underlying concepts of (product) innovation can be helpful in implementing D4S projects. This section discusses different approaches to innovation.

2.6.1 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*".

Most definitions of innovation emphasise 'newness' and 'successfulness'. There are distinctions made between *product* versus *process* innovations and sometimes amongst *market*, *business*, and *management* innovation. For example:

> Product innovation is the introduction of *new products* that have characteristics and/or use applications that differ from existing products on the market.

> Process innovation is the introduction of a *new method* of production that has not previously been used, or a new way of handling a commodity commercially, to make production more efficient or to produce new or improved products.

> Market innovation involves entering *new markets*, expanding existing markets, and/or developing new ways of serving customers.

> Business and management innovation involves developing new reward systems, organisational structures, and ways of handling responsibilities and human resources etc. that positively affects product sales.

D4S efforts usually focus on product and market innovation, while cleaner production is linked to process innovations and environmental management systems like ISO 14001 are associated with management innovations.

2.6.2 INNOVATION LEVELS

Innovation can be categorised into three levels: incremental, radical, and fundamental (see Figure 2-4). Each category is progressively more significant and far-reaching.

1> 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.

2> 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.

3> 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.

There is a wide range of innovation possibilities between the two extremes of incremental and fundamental innovation. 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. Successful incremental or radical innovation requires different kinds of thinking, working, and risk taking. For more insight into both types of innovation, a more detailed discussion of each is included below.

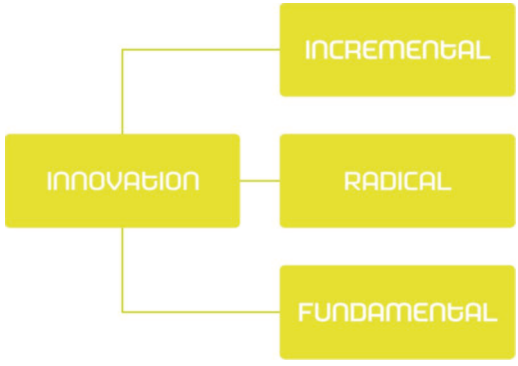


FIGURE 2-4 ___ DIFFERENT DEGREES OF INNOVATION

INSIDE-THE-BOX: INCREMENTAL INNOVATION

As the name suggests, this type of innovation makes small changes over a period of time. 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 risk. 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.

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:

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

In the well-known Ansoff matrix (Figure 2-5) these two types are included 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

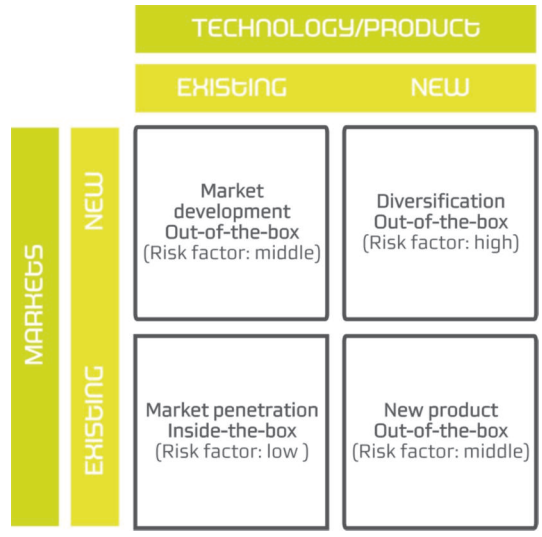


FIGURE 2-5 ___ THE ANSOFF RISK MATRIX FOR INNOVATION PROJECTS

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 with outside-the-box innovation are significantly higher than those associated with inside-the-box innovation. The outside-the-box innovation process is more volatile and the outcomes more uncertain; the time horizon also tends to be much longer.

THE NEED FOR RADICAL INNOVATION

To reach sustainability from a 'planet' point of view, large improvement factors are necessary, which can only be

reached with radical innovation.

Furthermore, radical innovation is increasingly becoming an economic necessity for companies. For years, incremental innovation and inside-the-box thinking were considered the most successful way to innovate, and that still might be the case for many companies. Recently however, many consumer goods companies are faced with poor returns on their investments because markets in developed countries have matured and sales of incrementally improved products are decreasing. In sharp contrast, sales of breakthrough innovations are shown to have dramatically increased. Another signal is the change in supply scenarios: resources and raw materials are becoming scarce and more expensive.

Clearly, the need for radical innovation is growing, not only from an environmental but also from an economical point of view.

2.7 A SYSTEMATIC APPROACH

A systematic approach for product innovation has been developed by Roozenburg and Eekels and is shown in Figure 2-6. It consists of four basic steps: 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 assessment. Of course an actual product innovation process will often be more chaotic, iterative, and less linear than described here, but the fundamental steps can usually be recognised and are necessary for successful innovation.

Part II of this publication presents guidelines and stepwise approaches for both incremental and more radical product innovation. Three common approaches to product design include: redesign, new product development and product-service systems and will be discussed in the context of sustainable product innovation. Each category has its own specific requirements and issues, but the basic four steps shown in Figure 2-6 are common to all.

FIGURE 2-6 ___ BASIC STEPS FOR PRODUCT INNOVATION

Figure 2-7 depicts the three main design approaches: Redesign, new product development and Product-Service Systems. The four basic steps are clearly shown for each. Chapters 4, 6 and 7 are devoted to explaining these design approaches in more detail and distinguishing the similarities and differences.

2.8 WHY DO D4S – DRIVERS FOR INDUSTRY

2.8.1 INTERNAL AND EXTERNAL DRIVERS FOR D4S

As described in the previous sections, there are compelling reasons for society to work on more sustainable solutions to the environmental, social, and economic problems the world is facing today. Furthermore, sustainability, corporate social responsibility, and related trends are part of the business agenda for an increasing number of companies worldwide. This is not only the case for most transnational companies, but also for a growing number of medium-sized and smaller companies. Understanding how to integrate these concepts into business planning can be an important part of a successful business strategy. Pressure to integrate sustainability requirements into corporate practices will come from government, business partners, non-governmental organisations, and citizen groups.

Motivation to implement D4S can come from within a business itself (internal drivers) or from outside a company (external drivers). Although there are overlaps amongst the people, planet, and profit aspects of sustainability, a driver is usually connected to one of them. Understanding the most influential drivers for a company or product can provide valuable information on the most effective types of D4S projects and activities to initiate. Table 2-3 presents common drivers for each of the three key elements of sustainability, people, planet, and profit.

For industry in developed economies, a mix of internal and external drivers for D4S generally exists, since

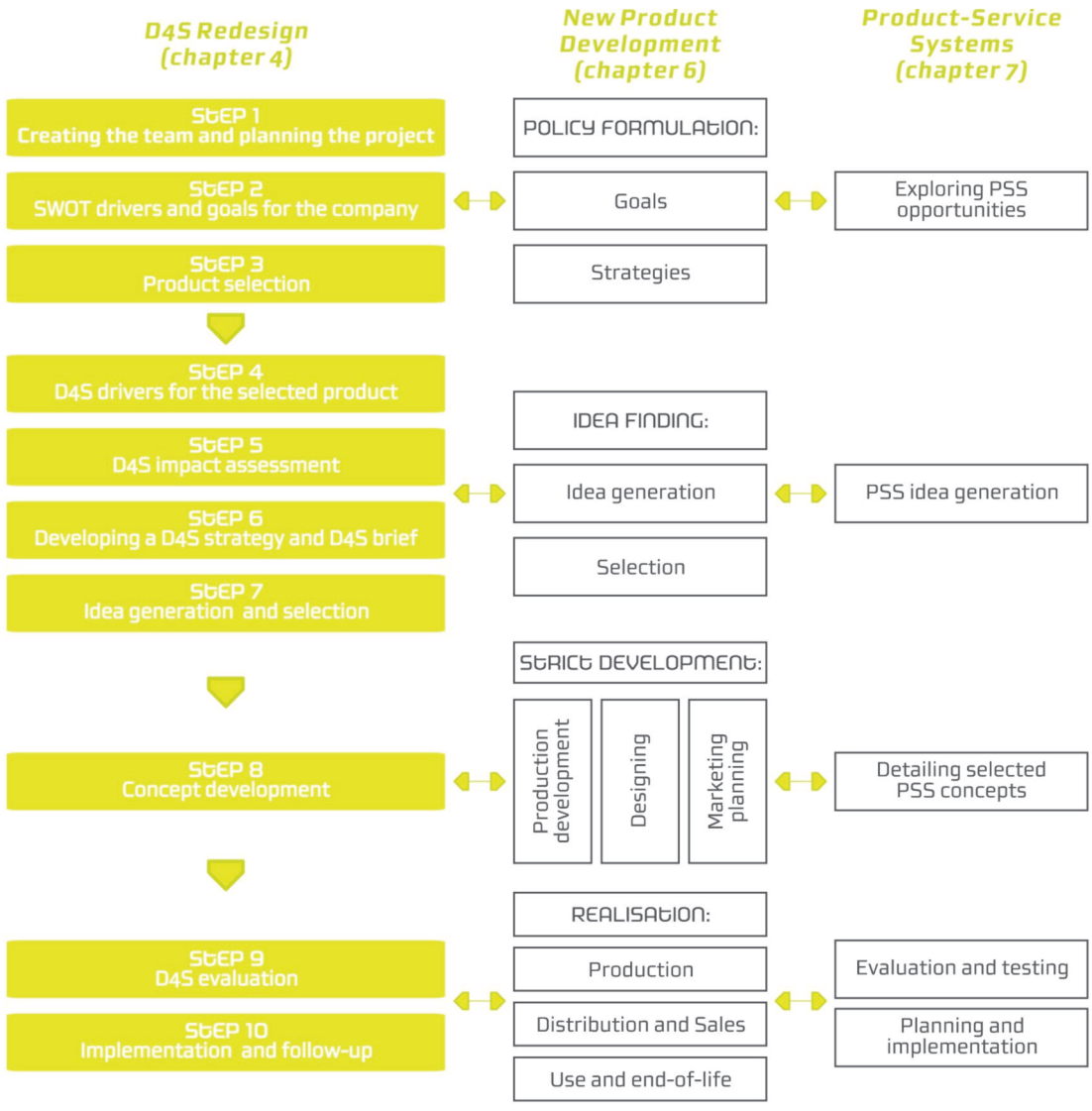


FIGURE 2-7 ___ THE THREE PARALLEL D4S APPROACHES OF THIS PUBLICATION

legislation, policy, and public opinion on sustainability are well developed. For industry in developing economies, internal drivers are more decisive for the initiation of D4S projects than external drivers, because external drivers currently are less developed.

2.8.2 BUSINESS OPPORTUNITIES AND D4S

Another way to evaluate reasons for industry to engage in D4S is to analyse the various business opportunities arising from these initiatives. The following three categories outline resulting business opportunities.

INTERNAL DRIVERS FOR D4S

'PEOPLE' ASPECT_

**Social equity** Can reduce risks on social and labour problems. As a result it can help avoid liability and reputation problems.
**Strong social policy** Can increase employee motivation. Employees can gain energy and experience from social projects and programmes launched by a company.
**Governance and management systems on social aspects** Can make company achievements more visible to shareholders and stakeholders.

'PLANET' ASPECT_

**Green marketing** The design and production of products with envi-ronmental value-added elements can boost brand value and reputation.
**Environmental awareness** Managers often are aware of the importance of environmental issues and want to act accordingly.

'PROFIT' ASPECT_

**Reach new consumers** Surveys demonstrate that consumers are increasingly ready to purchase on ethical grounds.
**Product quality improvement** Reliability and functionality often go together with a more sustainable product.
**Saving costs** Cost reductions can be made on material use, energy, waste treatment charges, transport and the distribution system.
_**Boost brand value and reputation**
**Product innovation** New possibilities from product innovation can find solutions to meet customer needs and wants.
_**Brand differentiation**
_**New opportunities for value creation**

EXTERNAL DRIVERS FOR D4S

'PEOPLE' ASPECT_

**Public opinion** Consumers are increasingly interested in the world that lies behind the product they buy, which is leading companies to take environmental and social issues into account.
**NGO pressure** For years industries have been under fire from NGOs for controversial practices and the related impacts on the environment. For example: Irresponsible company practices may lead to boycott campaigns which can cause significant damage to a company reputation.

'PLANET' ASPECT_

_**Legislative requirements** on environment will increase in many developing economies and can force a company into a more proactive stance.
_**Disclosure requirements** of environmental information towards suppliers and customers can start an improvement process in the company.
_**Ecolabelling schemes** can be an additional element for a companies' marketing strategy.
_**Consumer organisation requirements** such as safety, low toxicity and recyclability of products can be an incentive for D4S. Products failing to get 'a good score' on these aspects may no longer qualify as a 'good choice' in consumer tests.
_**Pressure from dedicated environmental groups** have forced industry to eliminate substances like CFCs from their products. These often highly professional organisations will continue to expose environmental harmful products.
_**Direct community 'neighbour' pressure** is often directed towards environmental and safety risks of the company and can have a large impact on production and products.

'PROFIT' ASPECT_

_**Norms and standards** on sustainability aspects of products will continue to become stricter and may force companies to improve products.
_**Subsidy schemes** are available in some countries to improve sustainability aspects of products and production. At the same time, subsidies on energy and raw materials are ending, forcing companies improve materials and energy efficiency.
_**Suppliers competition** is evolving to enter or remain in the supply chain, pushing companies to become more sustainable.
_**Customer demand** for healthier, safer and more environmental and socially responsible products is increasing in specific product categories.
_**Market competition** is growing as competition increases at local and global levels. Industry may look to improve innovative performance, which might include reviewing the sustainability aspects of their products.

TABEL 2-3 ___ INTERNAL AND EXTERNAL DRIVERS FOR D4S

> Cost savings and risk reduction opportunities

Some of the business opportunities can be realised in a short timeframe. For instance, if a company manages to cut back on the amount of raw material, energy, or water used, this translates to direct savings in production costs. Similar benefits can be achieved by lowering the costs for cleaning equipment, waste management, tax savings, and reduction of future liability risks.

> Enhancing image and market opportunities

D4S can be a decisive factor in the creation of new markets or in competition in existing markets. Also,

improvements in the quality of products improved by D4S can enhance the market position of the company. Furthermore, market research indicates there are a growing number of green investment funds offered by financial institutions: access to investment funding can be a beneficial effect of D4S implementation.

> Legislative, social, and business requirements

Societal concerns also signal business opportunities. In order to maintain their competitive edge in the market, companies will be required to address consumer concerns and take advantage of up-coming trends. In addition to the well known legislative requirements, buyer and supplier demand, and pressure from societal groups is becoming a more important factor.

An overview of the most common drivers from the perspective of business opportunities and challenges follows.

COST SAVING AND RISK REDUCTION OPPORTUNITIES

> Saving raw materials
> Saving energy
> Saving water
> Savings in emission and waste treatment
> Savings in environmental taxes and fees
> Savings in product transportation (distribution)
> Reduction of insurance costs
> Reduction of accident costs
> Reduction of future liability risks
> Postpone disposal costs by offering Product-Service Systems (PSS)

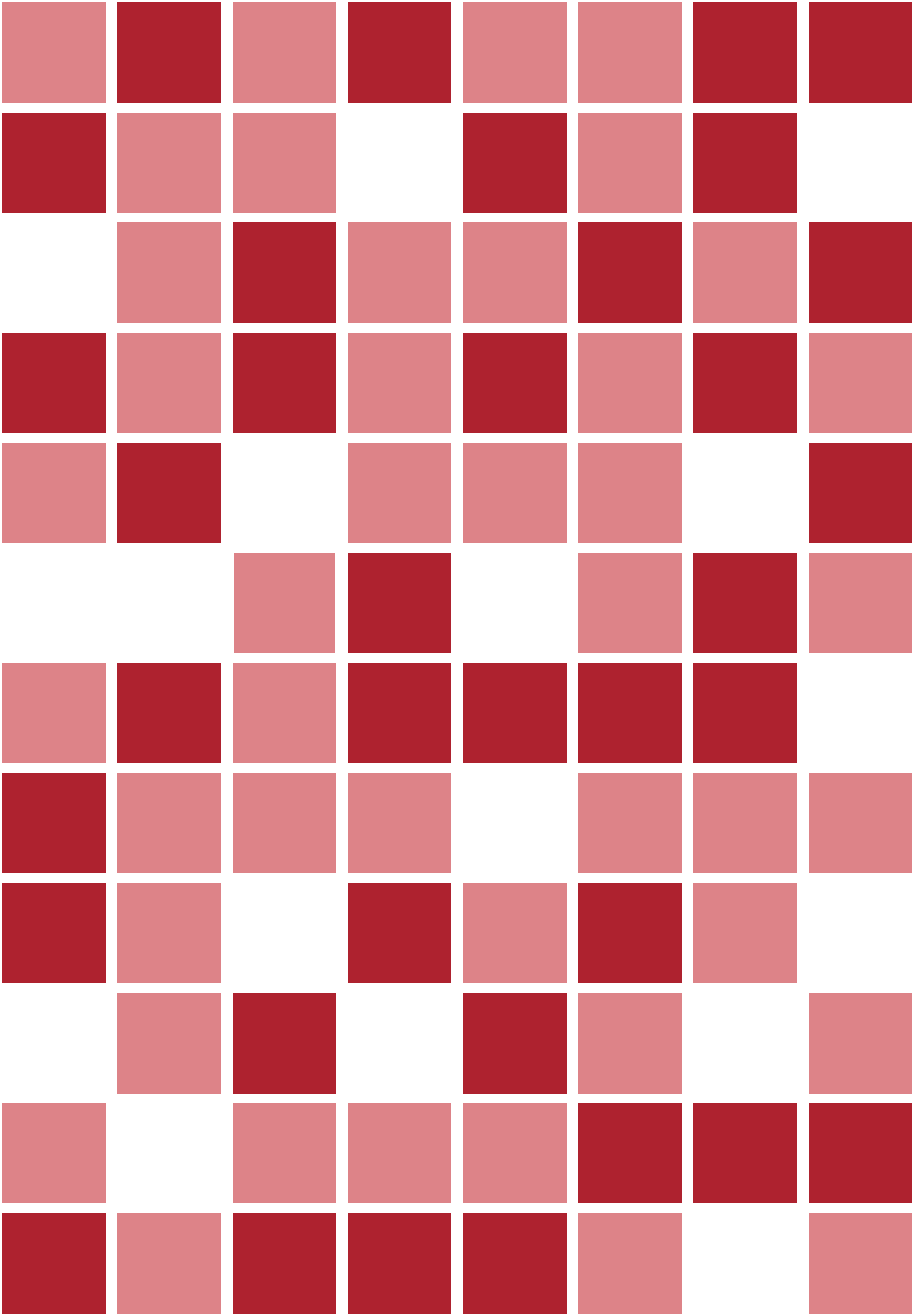
IMAGE ENHANCING AND BUSINESS OPPORTUNITIES

> Competition (retain markets, create new markets)
> Quality improvements that can enhance market position
> Customer demands (eco-labels)
> Branding and image creation
> CSR – Corporate Social Responsibility
> Improving worker health and safety issues
> Motivating employees and creating enthusiasm
> Enhancing innovation capacity
> Low profit margins call for new business ideas
> Improved access to green investment funding
> Building enduring producer-consumer relations by offering PSS

LEGISLATIVE, SOCIAL AND BUSINESS REQUIREMENTS

> Bans of toxic substances
> Take-back legislation – Extended Producer Responsibility
> Recycling requirements or recycled content requirements
> Emission limit standards
> Legislative information requirements
> Public procurement
> Buyer or supplier demands
> Pressure from environmental or other citizen groups
> Free customer of responsibilities for managing waste and hazardous substances by offering PSS

Case: A company committed to sustainability in all its aspects is Natura in Brasil. In the Case Study section on the web, the case of Natura is described with clear reference to the various drivers for D4S that influenced the strategic decisions of the company.



PLANET

PART II

HOW TO DO D4S IN PRACTICE

003 A 'QUICK-START' APPROACH TO D4S

CHRIS RYAN

OVERVIEW

THIS PART OF THE D4S: A STEP-BY-STEP APPROACH IS FOR THOSE WHO WANT TO QUICKLY COMMENCE A PROJECT.

The authors of the D4S: A Step-by-Step Approach have many years of experience in the practice of Ecodesign, design for environment or design for sustainability (D4S) as well as in the development of appropriate methodologies for different contexts, circumstances and business sectors. Ask any of them how projects get started and they will tell you that most begin with the vision and the determination of an 'inside' champion. If you are the first person in your organisation to open this D4S A Step-by-Step Approach, then it is likely that ***you*** are the sort of champion they would be thinking of – someone who wants to promote and facilitate action in your company or organisation to improve the environmental and social performance of your products or services. This 'Quick-Start Guide' is just like the first section of a software manual (often called something similar to 'quick-start') as it aims to help you get started, quickly, before having to read the entire Publication.

First steps towards the environmental improvement of products usually involve putting together a case for action, to 'bring others on board', developing a case that will persuade enough key people that this is a sensible and valuable thing to invest in. You will want to be able to present a persuasive argument that your company or organisations could produce product(s) which could be both more sustainable *and* more successful in the market. It will help your case if you can show that the design steps to delivering an improved product are neither too complex nor too expensive; it also helps if you can produce simple, clear, arguments about why embracing D4S is good business. This quick-start guide is one way to develop that case.

Note: The Power to Change.

This 'quick-start' guide comes with a warning: *batteries not included*. 'You' have to supply the energy to drive this change. Most successful examples of more sustainable products started with a champion. Sometimes that champion is a middle, or even senior manger, sometimes a designer or a technical person involved in production, sometimes a marketing person. Whatever position you hold in your company you need to do the work to develop the arguments and to find the examples which will work in your context. The D4S Step-by-Step Approach is structured with a layered approach to information – a broad overview, detailed methodologies relevant to various (product) contexts (with many good example projects), worksheets to help support various steps in the methodologies, and finally a large set of references to other guides to research and case studies to review. This should allow you to build up a body of information suited to *your* needs. In the end, however, this Publication cannot supply one critical element: *your enthusiasm and determination.*

HOW TO MAKE MOST USE OF THE D4S: A STEP-BY-STEP APPROACH WITH A PILOT PROJECT.

It is usually a good idea to begin a D4S process with some sort of pilot project, an exploration of the process of D4S using a real product that you have selected as appropriate. All the sections of this publication will help you with your projects. However, if you need to quickly understand what such a project would entail and to quickly present to your colleagues D4S possibilities for an existing product, then this is a good place to start. You will be able to consult the other sections of the D4S: A Step-by-Step Approach so 'pointers' are included in this text to the relevant page and section for you to refer to for a deeper understanding.

> *Hint: Starting Options*
> If you already have sufficient commitment within your organisation (and a decision to support D4S activity) then you can either just read quickly through this section or jump straight into the sections of the publication that seem most appropriate to your circumstances.

As you will see from the table of contents page, the D4S: A Step-by-Step Approach begins with an exploration of the 'what' and the 'why' of D4S or the social, business case, and environmental (People, Profit, Planet) drivers for D4S. It then moves on to the 'how', the actual processes for redesigning products or developing innovative new ones. In this **quick-start** section the order is reversed: we begin with a simplified 'how', focusing first on the steps to improving the sustainability of a product you have selected, or will select. Experience suggests that you will already have ideas about the 'Why' (it will be part of your motivation for taking on the role of champion) and that what you need first is some real sense of *what it will take* to improve *your* product. Of course you *will* need to develop a business case – the '*Why*'. There is a simple outline in this section that will help you structure your thoughts on that process, assuming that you will consult the longer discussion of motivation and drivers in the manual. [Chapter 2]

> *Note: D4S is deceptively simple.*
> The Quick-Start section begins with the simple – what D4S involves and (in general) how it is done. You will find that the concept appears remarkably simple; the steps to a better product can almost be described as a list of good design principles. Looking at such a list you will probably find it easy to think of products (in the market place) that have been improved by following the various approaches listed.
>
> But there is a deceptive part that you will need help in dealing with: determining what design approaches are *the appropriate ones for your product*, to address its specific environmental and social impacts and to find its competitive 'sustainable edge' (to maintain or improve its economic value whilst increasing its sustainability). *It is this deceptive aspect that is the reason for the D4S*: A Step-by-Step Approach, *it is why D4S and Ecodesign require a methodology and not just a list of design guidelines.*

Getting Started

Nine Simple Steps to Improving Your Product

In this Quick-Start we assume that you will run through a pilot or hypothetical redesign exercise for a product, in 9 steps:

> NOTE: These steps do not follow the exactly same sequence as the 10 steps in Chapter 4, because this is a simplified process and you do not yet have a team.

1. Select a product
2. Prepare a product 'dossier'
3. Review your product market – in terms of environmental and social issues
4. Reflect on your product in the light of a simple D4S list of approaches
5. Develop a quick picture of your product's 'impact profile'
6. Defining your product's improvement targets and design approaches

7. Redesign concepts – creativity at last!
8. Prioritising ideas and concepts
9. Making your case (for the real project)

STEP 1: SELECT A 'PRODUCT'

It is very likely that you already have a 'target' product in mind, presumably because market intelligence suggest that there are environmental and/or social characteristics of that product that are becoming critical to its future success. Or perhaps you are aware of societal or market pressures which could impact the reputation of your company. In this context we assume you intend to select a product as your 'case study' to explore its 'D4S potential'.

Experience has shown that selection of the first 'test' product should be made carefully. Generally the product should fit the following characteristics in that it should:

-Be in a market where its environmental and/or social characteristics are under scrutiny, or where there is competition from products claiming to be more sustainable

-Have a potential for change

-Be (relatively) simple

[See Chapter 4; Steps 2 and 3]

STEP 2: PREPARE A PRODUCT DOSSIER

You are going to need to know a lot about your product, perhaps in ways that you haven't had to think about before. Start a file or *dossier* on the product.

> *Hint: Just start collecting product information for your dossier now*
> You don't, at this stage, need to make this a detailed investigation. Start with whatever you know, or can discover quickly; you can keep adding to the information as you proceed. When a full pilot project is underway, this could become a collective activity, with members of the team adding information based on their knowledge. Tables 3-1 (a) and (b) below provide environmental and social impact areas to consider when 'filling out' your dossier.

The sections of the dossier should encompass (in no particular order):

***The Product and its Use*:**
> its history
> the original brief and the marketing plan for the current product
> market information (how it is sold, to whom, market share information)
> distribution and typical transport information
> typical product life
> typical 'user scenario' [Chapter 4; Step 5] – use patterns (including any resource inputs and waste generated – with rough estimates of amounts)
> typical end of life pathway (how products are recycled or disposed at expiration)

***Design and manufacturing*:**
> a breakdown of the key components and sourcing of the components
> materials list
> a simplified diagram or 'flow chart' of the manufacturing process [Chapter 4; Step 5] - including resource inputs and outputs (waste pollution) associated with each step (ideally with rough estimates of amounts)

***Competing products*:**
> other products in the market
> any defining characteristics (function, market segment, etc.)
> attributes of the product that are marketed as having environmental value
> relative performance data (often available from consumer or business magazines, internet sites, etc.)

Add two (initially blank) sections to your dossier to fill in as you go through the next steps:

Important characteristics of this product
> .....

Improvement ideas
> .....

STEP 3: REVIEW THE IMPORTANT ENVIRONMENTAL AND SOCIAL IMPACTS AREAS IN YOUR MARKET

For your product, and your market, you have to develop a sense of the priority areas which you need to address. What is considered a priority environmental or social issue will change from context to context. This is not a purely scientific issue, it also reflects local social and political issues – human rights, equity, labour – and of course, the economics of your product and its market.

> Note: It is very important to be sensitive to emerging issues; you will be redesigning a product that should last in the market for a good period of time. You do not want to get caught by issues which arise after you have designed and produced a new product.

Start by listing environmental and social issues which are currently important in your region and your market, for your customers. Review the competing products in your dossier to check what priorities are expressed. Consult company personnel about standards and regulations in your market. A generalised list is provided in Tables 3-1 (a) and (b) to guide your thinking. [For a more extensive list see Chapter 2, Sections 2.1 – 2.4

Impact Area	Impacts	Related Product Sources
Pollution of air	Greenhouse (carbon dioxide; methane)	Energy use, from fossil fuels
	Ozone depletion (CFC's)	Refrigerants; blowing agents (insulation)
	Acidification and smog (sulphur dioxide; nitrous oxide; dust; hydrocarbons)	Energy use, from fossil fuels
Pollution of water	Eutrophication Toxic contamination	Water use chemical use (eg phosphates, heavy metals, cleaning agents, pesticides etc)
Pollution of land	Solid waste / land fill Heavy metals (lead, cadmium, chromium, mercury)	Energy use, from fossil fuels Material waste Consumables End-of-life disposal
Resource depletion	Biodiversity reduction Extinction Resource scarcity	Fresh water use Use of scarce materials; non-renewable materials Total resource /materials use
Other	Noise Visual	Product and manufacturing operation

TABLE 3-1(A)___ ENVIRONMENTAL IMPACTS AREAS

Impact Area	Considerations	Sources
Human rights	Millennium goals; freedoms; legal protection; education; association	Materials or resource inputs; manufacturing; distribution – of product or components
Labour issues	Child labour; health and safety	As above
Governance and management	Control over social impacts; transparency in business; Corruption / bribery	As above

TABLE 3-1(B)___ SOCIAL IMPACTS AREAS

and 2.8 as well as Chapter 4, Step 2.] An economic impact table has not been included (although it is the third pillar of sustainability) because it is assumed that you are best placed to identify those for your company and product.

Mark (colour) on Table 3-2 those areas/issues which are most important for your product. Add any notes into your dossier in the 'important characteristics' section. You will use this information in Step 6.

STEP 4: REFLECT ON YOUR PRODUCT IN LIGHT OF THE SIMPLE D4S ASSESSMENT

Read quickly through Table 3-2 below, with your product in mind. Table 3-2 is one version of a common list of D4S approaches. Use it as a way to start thinking critically and creatively about possible product improvements. This will help you identify any missing information for your dossier. Use the two blank sections of your dossier to collect observations and ideas about your product characteristics and possible areas of improvement. You will return to this list later when you begin to select appropriate improvement option for your product.

Note: D4S approaches are product specific – there is no universal formula for success.
The approaches in Table 3-2 are easy to grasp. They require some complex decisions, but as approaches they are simple and not unusual as design specifications go. The approaches listed below should **not** be thought of as a checklist that needs to be followed for D4S action on a product. Nothing could be further from the truth. The approaches cannot all be applied to a given product. There are conflicts and trade-offs involved - if you follow one approach you might find that you then cannot follow another. For example, 'light-weighting' can reduce material inputs and the environmental costs of transport, but it might reduce the longevity of the product. More importantly, some of the design approaches will be unnecessary because they will not improve your product's environmental performance, they may actually make things worse. In practice it is necessary to identify *a selection* of the approaches listed that are appropriate *to improve the 'environmental and/or the social profile' of your product.* D4S requires more than simply following a list of design approaches, these approaches have to be embedded in a selection methodology in which you actively evaluate and assess each approach to determine the potential outcomes. This active evaluation of approaches for D4S is the reason for the D4S: A Step-by-Step Approach publication.

STEP 5: DEVELOP A QUICK PICTURE OF YOUR PRODUCT'S 'IMPACT PROFILE'

A D4S methodology relates the different design approaches to the environmental and social impacts of your particular product, providing a way to select those that will be relevant and fruitful.

Hint: Taking social and ethical issues into account.
If your answers to the social and ethical issues outlined in Table 3-2 showed them to be significant then you will need to ensure you become familiar with the strategies in the rest of the manual, particularly Chapter 2 and Chapter 7. Table 3-1 (b) is provided to ensure you have these issues in mind as you proceed. It may be that there are issues here that will be the driving force for your product redesign. If you start with environmental improvement of your product as the main driver then you should ensure that you do not exacerbate any social/ethical issues you have identified. Ideally you will be able to find strategies to resolve those issues whilst delivering environmental improvement.

In order to select design strategies, you need to understand the *environmental and social profile* of your product - a picture of how much each life-cycle stage (extraction of raw materials; processing of those materials; manufacture; distribution; use; end-of-life disposal; labour and human rights issues) contributes to its environmental and social impacts. Refer to Figure 3-1 below. (This is the basic approach known as 'life-cycle thinking',

Product characteristics	Strategic focus	Questions about your product (dossier information)	D4S / improvement approaches	Notes on Environmental effects
A. THE USE OF MATERIALS IN THE PRODUCT	**1. Selection of low impact materials**	*Can you identify any sensitive materials?*	(i) Eliminate materials with sensitive origins (e.g. rainforest timber), from non-renewable sources, or from endangered habitats, etc; or from economies where issues of human rights, labour exploitation or questionable development policies are prominent. Remember that 'renewable' materials are not without impact; always check the source data. Consider the 'social value chain' in materials selection. Link to C below – Social and ethical issues in production, distribution, and use.	Biodiversity and social concerns reduced.
		Are any materials high in embodied energy (or embodied water if that is a scarce resource in your market)?	(ii) The total energy and/or water used to create a product can be 'embodied' in its materials - the energy and/or water which goes into processing its materials. Reducing this can become a selection criteria for alternative materials. *Note: Embodied energy can be (partially) recovered through reuse and recycling. However, even recycled materials have an embodied energy (from transport, recovery, reprocessing etc.).* Embodied energy and/or water is an important issue but, to be significant in the selection of materials, 'total energy' or 'total water' is not an ideal measure because what is important is the pollution associated with the **form** of energy or the total pollution of the wastewater. What you really want from this indicator is how 'dirty' the energy or water is resulting from the production process, as well as how much of the resource is embodied. There is a move in many markets to define the embodied 'greenhouse gas' in materials, which more accurately reflects the energy impact of a material. Expect such data to become more readily available. Where it exists it is a measure that should be used for selecting alternative materials (or alternative sources of the same material). *Note: in the case of embodied water, recycled water is better than fresh (potable) water.* Link to D2(iii) and D2(v) next (Product Life-time and end-of life recovery) – embodied energy can be (partially) recovered through re-use and recycling.	The total energy used to create a product can be 'embodied' in its materials (i.e. in the energy which goes into processing the materials). NOTE this is true for recycled materials as energy is used in recycling (recovery, transport, processing etc). Link to A1(iv) below.
		Is anything in your product toxic to humans and/or ecosystems?	(iii) Eliminate toxic materials (e.g. lead or mercury) and any surface processing or treatments that introduce toxics in manufacturing, or which contaminate recovered/recycled materials [Link to A1(iv) or next below].	This is a critical issue for end-of-life paths; elimination of the toxic material will always be a more robust strategy than recovery and reuse/storage (where accidents can and do happen).
		Are the materials in your product able to be recycled?	(iv) Try to use recycled material.	Re-use and recycling assist in viable waste recovery, and can also help to recover embodied energy, but energy is used in recycling as well (recovery, transport, processing, etc.).
		Are there any recycled materials incorporated in the product?	(v) Use recyclable materials. Where possible Link to D2 Product life-time and end-of-life recovery (v).	Use of recycled materials builds the market for re-use of materials at end of (first) life.
		Could anything in our product be made from biodegradable materials?	(vi) Use biodegradable materials, if materials cannot be recovered at end of life. However be sure that a material is actually biodegradable in practice; landfills and compost systems do not always have the right conditions for things to biodegrade. Also biodegradable materials can contaminate recycling waste streams unless clearly labelled and separated.	Use of biodegradable materials avoids end-of-life waste accumulation.
	2. Materials use	*What is its total weight?* *Has the weight been optimised?*	(i) Think about the weight and structural issues of each component separately and reduce total product weight. Link to D: Product life-time and end-of-life recovery. A reduction in weight may have negative impact on product life.	A reduction in total product weight reduces overall resource flows in the economy (de-materialisation), lower extraction and processing impacts (less material consumed), lower transport impacts (a decrease in fuel consumption (Link to B2 Distribution and Transport).

TABLE 3-2 APPROACHES FOR DESIGN FOCUS AND RESPONSE

A. THE USE OF MATERIALS IN THE PRODUCT	*How many different materials are used?*	(ii) Consider the reasons for all the materials. Are there structural reasons for each material? Reduce the number of different materials. Use composite materials only if they lead to substantial reduction in total weight and if they can be recycled or reused at end of life.	Reduced materials can alleviate end-of-life concerns by easing recycling, materials reuse, and disposal.
	How are components and different materials joined? Could other joining systems be used?	(iii) Avoid bonding materials together; use mechanical fasteners or geometric patterns that allow components to be 'snapped' together. (iv) Use composite materials only if they lead to substantial reduction in total weight and if they can be recycled or reused at end-of-life.	Improves ease of recycling (by avoiding composite materials) and end-of-life materials capture. Link to D: Product life-time and end-of-life recovery.
3. Packaging	*What drives the packaging of the product? Safety, standards, image?*	(i) Aim to reduce material content and diversity of materials in packaging. Packaging is affected by product design, transport systems design, marketing, etc. as products may require packaging, for transport, for physical protection, to prevent tampering, and to advertise product (at point of sale). Whilst recognising these market limits, aim to reduce packaging materials.	Lower resource consumption (energy, materials, water).
B. THE USE OF RESOURCES FOR AND BY THE PRODUCT	**1. Production and Manufacturing**	*What are the key resource inputs?*	(i) Reduce inputs [Refer to product dossier or draw a simple flow chart of the manufacturing of the materials in the product and the product production itself.] Consider all inputs to manufacturing and processing of materials (including finishing and surfaces) and to the manufacturing of product components. Use new machinery, different processes, different process chain to reduce inputs and lower resource consumption (energy, materials, water).	Lower resource consumption (energy, materials, water).
		Are recovered resources, lower carbon energy sources or renewable energy already used in manufacturing the product? Are there opportunities for this?	(ii) Consider using renewable energy (or 'green power') or switch to lower carbon energy sources (e.g. from coal or oil to gas or biomass). (iii) Consider using recycled or recovered resources (e.g. water from one part of process as input to another).	Lower greenhouse gas emissions.
		What are the key outputs of pollution and waste? Can pollution and waste be reduced?	(iv) Consult the information in your dossier or draw a simple flow chart of the key outputs of pollution and waste. Carefully evaluate waste materials, resources and pollution. Reduce or reuse as much as possible through increased materials efficiency, etc. Identify potential uses for waste products in other manufacturing processes.	Reduce waste – increase materials efficiency.
	2. Distribution and Transport in all phases of the product life-cycle: logistics, distance, mode, and efficiency.	*What is the transport distance over the product's life-cycle?*	(i) Reduce transport distances; re-organise logistics of distribution to reduce total 'product-miles' (the sum of all transport distances of the product components and the products themselves).	Whatever form of transport used, energy is consumed, with waste heat and (usually) some pollution in proportion to distance travelled. By reducing transport distances, less energy is required and less pollution is emitted.
		How are products transported (what is the form or mode of transportation)?	(ii) Change transport mode to a more efficient or less polluting means (e.g. from truck to rail).	As noted above, whatever form of transport is used, energy is consumed, with waste heat and (usually) some pollution in proportion to distance travelled. Switching to a more efficient and less polluting mode of transportation will reduce energy required on behalf of transportation and generate less pollution is emitted.
		How efficient are the transportation systems?	(iii) Improve transport load efficiencies (higher utilisation rate).	Reduce resource use in transport. Less pollution is generated per product.
		Can the weight of the product and packaging be reduced?	(iv) Reduce weight of materials in the product as it is transported (see A2 (i) Materials use above).	Reduced weight requires less energy in the transportation of products and therefore less pollution.

B. THE USE OF RESOURCES FOR AND BY THE PRODUCT	**3. Impact in use**	*What resources does your product require to function during use?*	(i) Reduce resources consumed by the product during use (e.g. electricity, water, paper, ink, batteries) or substitute lower-impact resources. This segment of the resource-use can account for a large part of the total resources used throughout the product's life-cycle.	This can substantially reduce waste streams in the product life-cycle.
		Could your product use renewable energy? *If water is a significant issue in your market are there alternative sources of water that could be used (e.g. wastewater instead of fresh)?*	(ii) Use renewable energy when possible (e.g. solar energy to charge batteries). Also, use wastewater when possible.	For energy consuming products switching to renewable sources will reduce greenhouse gas.
		Can user behaviour affect the resource demands of your product in use? In what way?	(iii) Consider possibilities for low-impact user behaviour; could user behaviour and choice lower product use impacts? Provide users with appropriate information to promote the most efficient use of the product – through education, offering the product as a service (Link to E1: Meet user needs with a different product or service) with 'intelligent' feedback about implications of choices and operation (e.g. gauges, diodes or information screens). For many products, resource use depends on user behaviour, on operation processes, selection of options, etc (e.g. cars and dishwashers.)	Promoting consumer education to change user behaviour and influence consumer choice to reduce product impacts.
C. SOCIAL AND ETHICAL ISSUES IN PRODUCTION, DISTRIBUTION OF USE	**1. Improve the social and economic benefits of manufacture.**	*What social and ethical issues arise from production, distribution, and/or use? Do production and distribution conditions add to social and economic development? As part of this, how and where is the product manufactured (including components and materials)?*	(i) Ensure that components/materials are sourced from producers and/or markets with best practice social and labour conditions. Link to A1: Selection of low impact materials. (ii) Look for ways to provide a positive intervention to improve social and labour conditions. (iii) Review any ethical issues across product chain and seek resolution. These issues may be closely linked to a Corporate Social Responsibility (CSR) analysis or your company's CSR programme. There are valuable public sources that provide assistance in these initiatives. The following lists a selection of these resources: the UN global compact (http://www.unglobalcompact.org consult); Corporate Citizenship / Maplecroft Ethical Insight (http://www.maplecroft.com); local fair-trade sites (http://www.fairtrade.org.uk).	CSR can become a way of 'shaping' the design/innovation strategy of the company and has positive implications for image.
D. PRODUCT LIFE-TIME AND END-OF-LIFE RECOVERY	**1. Extending initial product lifetime**	*What is the average life of your product? How does this compare to other competing products? What determines the product life?*	(i) Make product more durable and reliable. Design for repair and/or refurbishment. Link to D1(iii) and D1(iv) below.	Making the product last longer reduces the material input and output flows by reducing the total number of products in use needed to deliver a given social result.
		Is there an aspect of 'fashion' about your product? Is that more than a veneer?	(ii) Product obsolescence can be driven by fashion not function. For products with some aspect of 'fashion', consider ways of changing product appearance without discarding the essential 'core' of the product (e.g. removable covers or shells) which could have a longer life. Link to D1(iv) below.	Decreases material flows (from total product to the 'fashion shell').
		Do users feel your product could age with them? Does it get more valuable as it gets older?	(iii) Consider ways of making product more valuable to the user with age (like an heirloom).	This could decreases material flows because fewer products are produced to fulfill function / user-needs.
		Can your product be conceptualised as a combination of 'long-life' and 'short-life' components?	(iv) Consider extending life of component parts rather than the whole product. Invest in quality and strength for those parts which can be reused or refurbished (e.g. removable head shaving razors). Link to D2(iv) (next page).	Decreases material flows.

D. PRODUCT LIFE-TIME AND END-OF-LIFE RECOVERY	**2. End of life systems.**	*How easy is product to disassemble?*	(i) Make sure all component parts and all materials are able to be easily disassembled at the end-of-life. This may require special tools, but it should be cost-effective (simplicity should be	This allows for capture of materials and components and their reuse where collection systems and the market exist and ultimately reduces resource consumption. Note: in whatever way this is done it will use energy (processing and transport).
		How easy is the product to reuse?	(ii) Design the product components (or the entire product) to be reusable at the end of its first life, either for the same purpose or alternative purposes. Components of a product should be able to be recovered and refurbished for reuse.	Reuse can avoid much of the energy costs of recycling products.
		Can the product be easily remanufactured?	(iii) Components or modules can be designed to be recovered and refurbished for reuse. Products can be considered as an 'assemblage' of components which can be either new or refurbished. Design initiatives should seek to increase the value of these components at the end-of-first life. Link to D2(iv) next below.	Can save significantly on energy and materials consumption.
		Can the product be designed as an 'assemblage of modules'?	(iv) *Modularisation*: Design the product as 'an assemblage of modules' which allows for reuse and refurbishment of modules. Examine modular design to allow for reuse of key high-quality components in future products. Ensure that the design evolution of the product can be based around some enduring high-quality components (able to be refurbished).	Necessary to achieve reuse/ remanufacturing.
		Can your product be collected at end of life to allow for reuse of components or recycling of materials?	(v) *Materials recovery:* Establish a recovery process that is practical and economic, such as returning the used product by post, or to a retailer, or through waste collection systems. As part of this, a framework should be established as to whom and in what fashion the materials will be recovered. As a final resort, after refurbishment and reuse, when ultimately the product or component has reached the end of all possible lives, then materials should be recovered for recycling.	Saves on the consumption of materials.
E. INNOVATION AND NEW PRODUCT STRATEGIES	**1. Meet user needs with a different product or service**	*Is the 'need' for the product – its value and utility – well understood? What is the 'service' the product provides?* *(NOTE: This has more than functional or technological dimensions – products also fulfill emotional and aesthetic and cultural 'needs')*	Clearly define the customer 'need' satisfied by the product and: (i) design a completely new product that meet that need with fewer adverse impact to the environment and society; or (ii) design a new set of products and services which together can meet that need, to fulfill that need with lower environmental and social impacts. Link to Chapter 7: Product-Service System design for a set of approaches to such services.	Various efficiency gains often on larger scales.
	2. Developing a hybrid product	*Could one product replace two or more existing products?*	(i) Combine the functions of separate products into one product to reduce the total number of products required to meet customer needs (i.e. phones with alarm clocks, answering machines, etc.).	Reduce the number of products required to meet customer needs and reduce materials and resource use.
	3. Exploiting new technological opportunities	*Are any new technologies or materials available which could provide the basis for innovation?*	(i) New technologies (e.g. photo-voltaic solar cells) can be the basis for a complete product innovation (Link to Chapter 6). New materials offer opportunities for new product ideas and innovation. (Link to E1 above).	Various efficiency gains often on larger scales.

the fundamental approach that underlies all aspects of the D4S process.) D4S methodologies can be complex because they aim to work for all products - to provide tools for calculating their life-cycle impacts and for deciding on the appropriate design strategies. But experience has shown that, for many products (particularly if it is the first time that environmental or social improvement has been attempted) there are short-cuts that can give useful results, particularly for a pilot project.

At this point you have two options:

• *You can set up a small workshop* and conduct a qualitative evaluation of the life-cycle impacts of your product (see Note: 'LCA and Expert Workshop' Box below). If you decide to do this turn to Chapter 4 in the D4S: A Step-by-Step Approach and follow the process set out there.

• *You can work on your own* (with whatever guidance or help you can elicit from colleagues).

We assume that you are likely to proceed on your own, with some help from colleagues, but that you are unable at this moment to mount a full workshop process. Go back to your product dossier and (in the section on important characteristics) write down what you know about your product's **inputs for each life-cycle stage**; energy (note what kind of energy); water use (note what kind of water – fresh or recycled); other resource, or consumables, use (note what kind) and the social elements surrounding product production (labour policies, health and safety in the workplace). Find out if there are any toxic materials in the product (at what life-cycle stage do they enter)? Next consider outputs: **what pollution, waste, or adverse social impacts is created at each life-cycle stage**. *Draw up a simple product life-cycle diagram and note on that diagram (see Figure 3-1 below) using all the data that you have collected.*

Note: LCA and Expert Workshops

Product inventory data can be inserted into a variety of software systems that calculate a life-cycle impact profile, which quantifies environmental and social impacts across all the life-cycle stages. The results of a life-cycle assessment (LCA) can provide insight into which phase of the product's life-cycle has the largest impact. This information can be contrary to what might be expected. For example, a life-cycle assessment of a product might find that the total *solid waste* created by the energy (electricity, gas, petrol, diesel) required to operate the product over its usable life, is several orders of magnitude larger than the total weight of the product itself. In this case the 'use-impact' will be much more significant than end-of-life disposal.

A full quantitative LCA is quite complex and generally costly. While a full LCA is desirable (and is the approach taken by many large companies) the cost and complexity leads many producers and designers to downscale the effort to an *expert workshop*. The expert workshop is an alternative approach to product assessment. (Even for companies possessing the resources necessary for conducting full LCA studies, the expert-workshop approach can be an effective way to assess the potential positive outcomes of a D4S pilot project.) The workshop usually requires a mixture of people who are knowledgeable about the different production and use aspects. This includes insight from a technical, manufacturing and performance perspective (those who supplied the product data) and additionally the people who are aware of the environmental and social impacts. Unlike LCA software systems, the expert workshop will not always produce quantified data about the contribution of each of the life-cycle stages to a particular environmental or social impact. Expert workshops generally deal with a mixture of quantitative and qualitative data to provide a sense of relative values and impacts. Generally, the participants are asked to rank the contribution on a limited scale (e.g. zero; low; medium; high).

Expert workshops of qualitative life-cycle assessment will often involve reflection on a full LCA carried out on a similar product. Many studies which have compared the results of an expert workshop process and a full quantitative LCA have shown that the expert workshop gives excellent results and for less money and time. [See Chapter 4 Step 5]

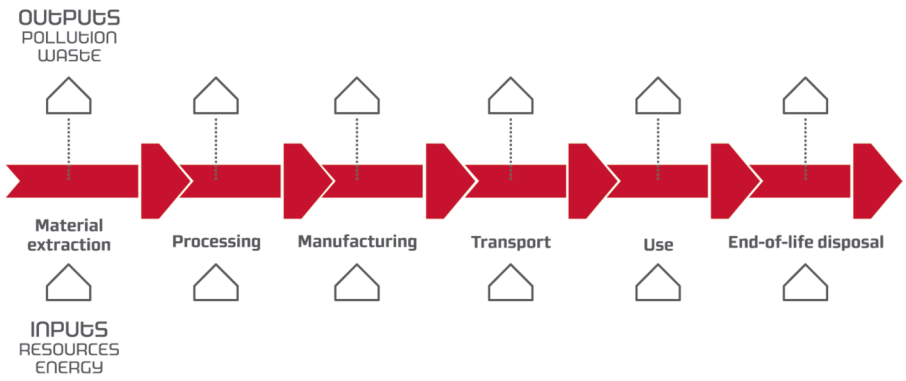


FIGURE 2-1 PRODUCT LIFE-CYCLE

Table 3-3 lists key categories of product use, provides impact profiles for each of the use scenarios, and the types of information needed to better assess life-cycle impacts. Now consider where your product fits in Table 3-3. Check the column 'product type/characteristics'. Find the characteristics that best match your product and review the impact profile in the centre column. The 'impact profile' concisely identifies the most significant life-cycle phases of the product; this information is based on knowledge gained from full life-cycle impact assessments of a large number of products which have been the focus of design for sustainability.

Note: products may cover more than one of the 'types', so you will have to combine the average impact profile information.

STEP 6: DEFINING YOUR PRODUCT'S IMPROVEMENT TARGETS AND DESIGN APPROACHES (A SIMPLIFIED DESIGN BRIEF)

You now have almost all the information you need to proceed to identifying D4S strategies and design responses that address the life-cycle phases and product characteristics requiring focus.

Note: Remember this is not a precise process but an approximate way of narrowing down the focus for action and reducing the complexity of decision making. For a real project requiring investment and risk, you will need to follow the detailed processes and tools set out in the D4S publication.

The information in the centre column in Table 3-3 (typical impact profile) tells you which are likely to be the most significant life-cycle stages for your product; go to the Figure 3-1 on which you have marked the inputs and outputs of your product and circle those that are noted as most significant. Now consider the 'Knowledge Focus' column, in Table 3-3 above, and check if that data is already in your dossier; if it is not, you will need to find (or estimate) this information. Now look at the final column 'Most relevant D4S responses' for the reference points linking back to Table 3-2. Following these reference points, highlight those items in Table 3-2 that best match the needs of your product. *You will use this marked table, the 'ringed' life-cycle diagram and the information in your dossier in the next step.*

Hint: take four large sheets of paper and write out:

1. The main issues for your product in your markets – from Table 3-1 (a) and (b);
2. The marked life-cycle diagram;
3. The list of highlighted approaches (from Table 3-2);
4. Key information from your dossier.

Hint: Hang these four sheets up in the room you are using to work on the pilot project. Leaving them up for a period of time, even when you are not working on the project can be a great way of stimulating ideas. It can be useful to have a fifth sheet – initially blank – for writing down ideas when they come to you.

Product type / characteristics		Typical impact profile	Knowledge focus (data you will need to gather for your product)	Most relevant D4S responses (the references link to Table 3-2 above)
1. An active product ? Does your product consume energy in order to function? If so what kind of energy (the critical issue is CO2 produced, but there are other aspects of pollution from energy production and distribution). You could consider 'water' as well as energy in this question, if it is appropriate to your product category.	(A) **YES**	It is highly likely that the most significant impacts for your product occur in the 'use-phase', from its energy (or water) consumed during use. NOTE: Even if the energy already comes from a renewable source or if the water is recovered wastewater you can still improve these features. Please consider the 'passive product' next below.	- lifetime and use patterns; -product operation (where energy is used); -the kind of energy sources (their greenhouse gas contribution); - overall power consumption; - efficiency of key components (e.g. motors).	B 3(i); (ii); (iii) (energy/water focus) E1, E2 and E3 (Lower priority: A2(i) and D2.)
	(B) **NO** (Passive product)	Then the key impact areas will be in the materials extraction/processing, manufacturing and end of life. Use-phase impacts will be low. *Caution:* watch for maintenance inputs for use phase (e.g. cleaning).	Materials; manufacturing systems; factors affecting the life of the product. (Generally, for this category, extending the product life reduces environmental impact).	A1 A2 A3 B1 B2 C1 D1 (High priority) D2
2. A mobile product? Is your product mobile or transported when in use? (e.g. a car or a container)	(A) **YES**	The use phase is likely to be important as product mass will create indirect use of energy for transport. However, as mass is related to materials processing and end-of-life, impacts in these phases need to be considered as well.	Use patterns; product life, transport distances over life; materials choice; issues of product weight; energy or fuels used for transport; end-of-life disposal patterns.	A2 (i). B2 (i); (ii); (iii); and (iv) B3 (i); (ii); (iii) Consider inputs to the mobility/transport process C1
	(B) **NO** (Stationary product)	No conclusions. Examine other characteristics.		
3. A consumables product? Does your product require consumables to operate? (e.g. batteries; chemicals; inks, paper etc.). [Many such products will also be in group 1A Active Products (this table above).]	(A) **YES**	Impact profile similar to 1A Active Products above – the use phase of your product is important. However, in this case you have to consider the life-cycle of the consumable products as well. You may gain product improvement by specifying different consumables.	Use patterns; data on the consumables, their impacts, typical amounts consumed over total product life; alternative or substitute consumables.	B3 (i); (ii); (iii). (equal emphasis on reduction of consumable use, selecting low-impact consumables, substituting renewable consumables – e.g. rechargeable batteries) C1 E1 (i); (ii) E2 (i) E3 (i) (Lower priority: A2; A3; D2)
	(B) **NO** (Passive product)	Consider 1B Passive Products (this table above).		
4 A short-life product? Is your product a consumable, a non-durable, a use-and-dispose?	(A) **YES**	Impact profile will emphasise beginning and end-of-life.	Use patterns; total volumes of materials, end-of-life disposal patterns; materials choices to reduce impacts at manufacturing and end-of-life and to extend life.	A1; A2; A3 B1; B2 C1 D1 (Note: not appropriate if product is also a 1A [Active Product] or 3A [Consumable Product] type) D2

TABLE 3-3 ___ PRODUCT TYPE, IMPACT AND RESPONSE

STEP 7. REDESIGN OPTIONS (CREATIVITY AT LAST!).

The data (on your large sheets of paper) now becomes the focus for creative redesign ideas. Here you need creative processes and (if you can) a few people to help you brainstorm [See Chapter 4, Step 7). Draw up a table on another large sheet of paper with the selected life-cycle stages across the top. On the left column mark the various D4S design responses that you highlighted in Step 6 above. Now you can proceed by addressing each cell of this table, asking the following questions:

- Is this focus/response relevant to this product life--cycle?
- What design options are appropriate here?

Write your creative ideas in each cell. Check back through any ideas that you have jotted down. Investigate possibilities. Follow normal brainstorming procedures; get ideas on paper without self-censorship (this process may take a number of days, because you may need to brainstorm, break, and then return to the task when you have the time). When you finish and are finally run out of ideas, it is finally time for a 'reality check'. (Again this will be more effective if can combine the insights and knowledge of a number of people within the company, but you can start this process on your own with a little research.)

Using whatever notation you like (coloured dots; 'high', 'medium', 'low'; 'A';'B' 'C'; ticks or crosses, etc), consider each cell in turn and rank each of the ideas you have written, consider the three questions:

- Could this deliver significant environmental and/or social improvement?
- Can it be done cost effectively?
- Will this help improve my product in an area that is important in my market - or could such an improvement be used to market this product or differentiate it from the competition?

STEP 8: PRIORITISING IDEAS AND CONCEPTS

Now you have a series of ideas with some estimation of their environmental, social and market value. Place each of the ideas into four categories on the following Table 3-4.

Any ideas that fall into the bottom left cell (4) can be discarded. Those in the top right (2) should be given the most serious attention. (Ideas that sit in cell 3 may indicate some quick improvements that can easily be implemented in the short term.) For the ideas selected (from cell 2 and perhaps cell 3) there will still be different degrees of difficulty and cost as well as different degrees of environmental (and social) gains. You will need to prioritise these. [Chapter 4 and Worksheet 7 provide some detailed processes for prioritising your possible design approaches.] Ideas in the bottom right and top left will need to be further researched to see how their technical, cost and market problems can be overcome.

You now have a list of product improvement and redesign ideas to take forward within the company.

1	2
Significant environmental (or social) gains Technically or economically difficult or uncertain	Significant environmental (or social) gains Technically or economically feasible
3	**4**
Limited environmental (or social) gains Technically or economically difficult or uncertain	Limited environmental (or social) gains Technically or economically feasible

TABLE 3-4 ___ PRIORITISING D4S IDEAS

STEP 9: MAKE A CASE FOR D4S WORK IN YOUR COMPANY – GET RESOURCES AND SUPPORT FOR A PILOT PROJECT.

In Step 8 you identified a range of possibilities to improve your product and reduce its overall life-cycle impact. You are now in the position to make a case for undertaking a full pilot project within your company or organisation:

Aim: *to increase awareness; explain concepts; motivate people; win support and resources to proceed with a more detailed project.*

Target: *management, design, and marketing personnel.*

This step involves preparing a Business Case for undertaking a full pilot project. This report is likely to contain three sets of information:

- The broad strategic case for addressing D4S within your company
- A report on all the work carried out in Steps 1-8
- Ideas for marketing a new product with strongly improved environmental and social features.

You may need some help in putting this case together, but you must have thought the business case was clear and strong when you initiated this quick-start approach. The following is offered only as a stimulus for organising your ideas.

Hints:

Be proactive: Go back to Table 3-1 and make a list of the environmentally-related laws, regulations and standards that will affect the market of your product. Make a list of any social and/or ethical issues in any of the markets from which your product draws materials or components. Try to identify any movements for change in those areas and consider scenarios for how those changes could affect the market position of your product. Consider all markets that your product will enter – are some countries or regions more advanced (or more stringent) in their regulatory action than others? Consider consumer sensitivities: Make a list of what customers are demanding. Look closely at the way demands are changing. Consider scenarios for how those changing demands could affect your market. Consider brand and reputation: What aspects of your brand or your company's reputation depend on being environmentally and/or socially responsible. What environmental and/or social issues are most important in improving that brand and reputation. What does the consumer choice/media say about your product? Have any of your competitor's products been criticised for environmental or social affects? What does staff think about the environmental and social commitment of the company and the quality of its products?

Arguments for embarking on a D4S project can be grouped into three sets of motivations and these provide a simple way to organise your case:

Legal and social obligations – must do it!

Any existing legal requirements (safety standards, chemical regulations, materials bans, pollution monitoring, control, reporting, take-back requirements, and so on) will already have impacted your product design and sales. Social and ethical issues within your markets will have been considered in Step 4. The critical issue is to understand *trends*, not just the current conditions but to project likely future requirements. Develop the case relating to trends and the value of being ahead. Products can have a long-life in the market and anticipating change is usually better (and less expensive) than reacting to it (making whatever adjustments to existing products that become necessary to meet new requirements). Companies that have sought 'first-mover' advantage by anticipating new legal frameworks (for example on recycling or eliminating sensitive materials) sometimes find it is to their advantage to actively lobby to speed up the regulatory change they anticipated.

What do consumers say?

Be sensitive to consumer preferences: Make a list of what customers are demanding. Look closely at the way demands are changing. Consider scenarios for how those changing demands could affect your market. Consider brand and reputation: What aspects of the brand or the company's reputation depend on being environmentally and socially responsible. What environmental or social issues are most important in improving that brand and reputation? What does the consumer choice media say about the product? Have any of the competitor products been criticised for environmental or social affects?

Financial analysis – it is worth it!

List the economic returns possible: Reduced cost (due to energy and materials savings); improved market share (getting ahead of competitors by reputations and environmental/social quality); brand recognition and reputational returns; avoiding risk by being pro-active.

Improved morale and commitment – it is good to do!

Consider the social motivations for improving the local or global environment and assuming responsibility for your actions. Who will this effect and how will it contribute to the success of the company?

D4S is one important aspect of corporate social responsibility, with both 'internal' and 'external' rewards. It represents a commitment to the long-term economic sustainability of the company. Developing a strategy to improve your product not only improves your external reputation but it improves morale and commitment and motivation within the company. People prefer to come to work for a company that is assuming a responsibility for its impacts, particularly when that is evident in its products.

[For assistance with marketing your future product read the communication, Module G on the web.]

NOW TURN TO WORK WITH THE D4S: A STEP-BY-STEP APPROACH. IT SHOULD PROVE VERY REWARDING – FOR YOUR COMPANY, PEOPLE AND THE PLANET.

04 INSIDE-THE-BOX: D4S REDESIGN

MARCEL CRUL AND JAN CAREL DIEHL

As the name implies, D4S Redesign aims at redesigning an existing product made by a company, including its primary function and any associated services provided, 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. In contrast to more radical types of product innovation, redesign usually follows a predictable, stepwise process and is as economically and commercially important as more radical approaches for many companies. Because the focus of D4S Redesign is on an existing product, the specific market and manufacturing conditions are already known. A product's improvement potential can easily be determined from available information, including feedback from the sales department and user experiences, testing and market investigations. In addition, the existing production facilities are usually suitable for manufacturing the redesigned product so, investment costs are likely to remain within reasonable boundaries. The risks associated with redesign efforts are lower compared to the more radical D4S innovation approaches that are described in the next chapters. As discussed in Part I, redesign is often a good approach for a first D4S pilot project in a company.

Box 4-1: Another approach focused on redesign of existing products is D4S benchmarking of a product against those of a company's competitors, leading to improvement options. This approach is explained in detail in Module A on the web.

4.1 A STRUCTURED, STEP-WISE APPROACH TO D4S REDESIGN

A typical D4S Redesign approach has 10 steps, as illustrated in Figure 4-1 below. These steps can be grouped according to the 4 basic steps for product innovation (goals and strategies, idea finding, strict development, and realisation) as shown in Figure 2-6 in Chapter 2. In redesign, the formulation of goals and strategies is focused on the existing product (Steps 1-3). The idea finding steps are limited to the selected product so the assessment can be very specific (Steps 4-7). In most cases, existing production and distribution resources are used to create the product, hence the realisation phase is relatively straightforward (Steps 8-10).

In the following sections, each step is explained, and a reference is made to the related ***Worksheet set R (redesign)*** that can be found on the accompanying web.

STEP 1: CREATING THE TEAM AND PLANNING THE PROJECT

A D4S Redesign team will be responsible for introducing and implementing D4S Redesign procedures at the organisational and technical levels. The team needs to identify people inside and outside the company who will be involved in the project and determine how each one can best be used.

Ideally, the D4S Redesign team will have members with different areas of expertise. The goal is to involve product developers, environmental experts, employees in the sales and marketing departments, and senior management in the redesign process. If appropriate, finance and quality control departments also can be involved. The marketing department is critical in D4S Redesign activities. Experience shows that the marketing department is key in sharing knowledge about consumer needs and wants and in marketing the redesigned product.

The team needs the full support of senior management and product managers because they control budgets and product strategies. Other key stakeholders outside the company (knowledge institutes, universities, dedicated consultancies, sector organisations, or partners from local or regional clusters) can be asked to

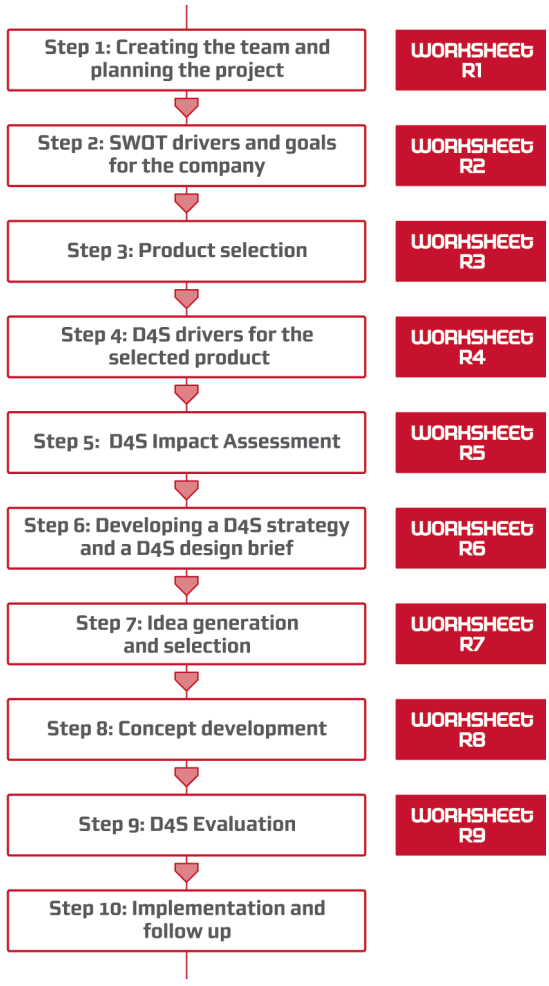


FIGURE 4-1 ___ D4S REDESIGN STEP-BY-STEP

join the project team or monitoring committee as needed. External expertise may be required when specific experience or knowledge is not available inside the company. Advice can be provided by an external design or innovation consultant. This advice might be limited to targeted needs within specific phases of the project. Collaboration with local industrial design schools can support D4S projects with interns or graduate students.

The D4S Redesign team should not be too big (preferably no more than 6 people) and should try to have the following characteristics:

> Creative ability to generate new ideas;

> Decision-making capacity;

> Communication skills within the team and the organisation;

> Multi-disciplinary; and

> Well organised and operational.

The role of each team member should be clarified at the beginning of the project along with specific tasks and responsibilities to optimise the process.

> *Which departments and staff members will be involved in the D4S Redesign team? What will the specific roles in the team be?* > ***Worksheet R1***

An essential prerequisite for the successful introduction of D4S Redesign – as in all implementation processes – is motivation of those involved in the project. There are three basic ways of convincing people of the relevance of D4S Redesign: 1) highlight business benefits, 2) provide good examples of D4S Redesign products and resultant benefits, and 3) list convincing sustainability arguments. In addition, successful D4S Redesign projects can motivate company employees and help to integrate D4S Redesign into the company after the demonstration project is completed.

The first priority for the D4S Redesign team is to develop a clear action plan and to identify the expected deliverables. Most D4S Redesign projects take from three months to a year to complete, depending on the product innovation capacity of the company and the complexity of the product that is redesigned.

> *Discuss the timeframe of the project: What will be carried out? How often will the team meet and how they will communicate with the rest of the organisation?* > ***Worksheet R1***

STEP 2: STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS, DRIVERS AND GOALS FOR THE COMPANY

The D4S Redesign process is essentially the same as a conventional product development process but its goal is to integrate sustainability criteria into the process. As a result, D4S Redesign is interwoven with normal product development and businesses activities within the company. Given this integration, the company's overall

objectives and current situation should be taken into consideration as well as specific sustainability concerns.

In order for a D4S Redesign project to be successful, it is important to have clear goals and expectations from the beginning. The team should ensure that project goals are aligned with the company's policies, business plans, and other strategic objectives.

A strengths, weaknesses, opportunities and threats (SWOT) analysis outlines the current product innovation capacity within the company and provides an overview of relevant D4S drivers. Based upon this analysis the team can define D4S Redesign project goals and assess the level of ambition and innovation within the company.

SWOT Analysis

It is useful to get a picture of the competitive position of the company before proceeding with a D4S Redesign project. The SWOT matrix is a useful tool to facilitate this process. It analyses a company's internal strengths and weaknesses as well as external opportunities and threats.

> *Identify the internal and external conditions a company is operating in and fill in the SWOT Matrix.* > ***Worksheet R2***

Product innovation capacity within a company is based on prior product innovation experience and staff competence. This capacity assists in the identification of appropriate D4S innovation goals for a company.

> *What is the company's main activity? Does the company develop and produce final products (product-company) or does it use production capacity to provide services for other companies (capacity-company)?* > ***Worksheet R2***
> *On average, how many redesigned products and how many new products are launched into the market annually?* > ***Worksheet R2***
> *Does the company have a product development department or do they normally contract out design services for product development?* > ***Worksheet R2***

D4S Redesign drivers

Why does the company want to carry out D4S initiatives? What are the D4S drivers for the company? Sometimes a company might be forced by external drivers like environmental or social legislation or supply chain requirements. However, often the project will be driven by internal company demands, such as cost reduction or corporate social responsibility. Generally there are one or two major drivers influencing D4S decisions. Even if the drivers are obvious, they should be identified during the initial project stage, and other potentially relevant drivers should be evaluated (see Chapter 2 for an overview of D4S drivers).

> *Identify which internal and external D4S drivers are relevant to the company and prioritise them.* > ***Worksheet R2***

The internal and external D4S drivers are related to the three different pillars of sustainability: people, planet, and profit. In some projects the objective is to find a 'perfect balance' between them. Other projects may have a specific focus on environmental aspects (planet) or social aspects (people).

Goal of the project

After carrying out a SWOT analysis, the team has a better understanding of the competitive position of the company and the internal and external D4S drivers. The team can now address the following questions:

> What **must** the company do?
Because of environmental laws, labour laws, or customer demands.
> What does the company **want** to do?
Because of cost reduction, improved market position or assumed corporate social responsibility.
> What **can** the company do?
Depending on available financial and human resources and product innovation capacity.

Specific D4S project goals are defined based upon the answers to these variables. The goal(s) of a D4S Redesign project can vary depending on the company priorities and capacity as defined in this step. Examples of possible goals are given below.

Possible goals for D4S Redesign projects:

> To show that the sustainability of a product can be improved;

> To show that the sustainability of the production process can be improved;

> To gain insight into the sustainability impacts of a product's life-cycle;

> To communicate sustainability aspects of a product to the market;

> To demonstrate that D4S can contribute to the economic performance (cost reduction) of a company;

> To prepare a company and its product portfolio to meet upcoming legislation requirements;

> To prepare a company to face critical demands from civil society and stakeholders;

> To enter sustainability niche markets with sustainable products; and

> To bring down the end-of-life cost of a product.

Experience shows that for a first project, the D4S Redesign team should establish goals that can be achieved in a relatively short timeframe. This builds a foundation of support and confidence for future projects.

> What is the goal of the D4S demonstration project? **> *Worksheet R2***

Step 3: Product Selection

Companies often use intuition to select the product for redesign efforts. However this approach may not result in the selection of the most appropriate product and may reduce the chances of project success. Therefore, product selection criteria should be derived from Step 2. The product should be one that is affected by identified D4S Redesign drivers and in line with the D4S project goals resulting from Step 2.

> Based on Step 2, what are the product selection criteria? **> *Worksheet R3***

If possible, the product should:

> Have sufficient potential for change;

> Be relatively simple (in order to achieve fast results and to avoid extensive research); and

> Be affected by the identified D4S drivers for the company.

> Select a product out of the company portfolio that fits the defined D4S product selection criteria. **> *Worksheet R3***

Step 4: D4S Drivers for the Selected Product

Does the selected product meet the drivers and company goals for the D4S Redesign project? It is possible that the D4S drivers identified in Step 2 apply to the entire product portfolio but are not relevant to the selected product. After the product is selected, the D4S Redesign team should cross reference the internal and external D4S drivers for the proposed product are in line with the overarching company goals. This will help ensure that the optimal product has been selected for the D4S Redesign efforts.

> Determine which internal and external drivers are relevant for the selected product and prioritise them. **> *Worksheet R4***

Step 5: D4S Impact Assessment

A successful D4S Redesign project is based on an understanding of the sustainability impacts of the target product during its lifetime. The product life-cycle can be assessed on the three sustainability pillars of planet, people, and profit.

There are various qualitative and quantitative methods for assessing the sustainability profile of the product. The analysis can be very detailed and time consuming, as in the case of a life-cycle assessment (LCA). The more quantitative assessment methods (often supported by LCA software) can provide quantifiable estimates of project impacts. (See the list of references at the end of this publication).

D4S Redesign projects implemented by large industries should, to the extent possible, have well defined project impact criteria and a thorough monitoring framework in place to capture the quantitative impacts of the project. SMEs, on the other hand, should employ more simple and qualitative sustainability assessment methods. Comparatively, SMEs have relatively few staff, expertise, data and available finances. In addition, the social aspects can be assessed on a qualitative or semi-quantitative basis.

The main goals of a D4S Impact Assessment are:

> To understand the major sustainability aspects of the product life-cycle; and

> To identify sustainability priorities of the product life-cycle.

A D4S Impact Assessment consists of 5 steps:

1> Creating the life-cycle process tree;

2> Defining the user scenario and functional unit;

3> Identifying D4S impact criteria;

4> Filling in the D4S Impact Matrix; and

5> Prioritising the D4S impacts.

1> Creating the life-cycle process tree

The project team should first decide on the exact area of study – known as the functional unit - and the boundaries of the assessment. A process tree can be used to identify the key stages in the product life-cycle and the boundaries of the system. This can be done by noting the major upstream stages, such as the extraction and processing of raw materials, and the major downstream stages, such as packaging, distribution and transport, sales, use, disposal, and recycling. The life-cycle process tree is important because it documents all the stages of the product's life-cycle that need to taken into account. It can help to identify life-cycle stages that might otherwise be overlooked. It also helps the team identify the stages having larger impacts which can then be used to prioritise specific product areas to enhance the effectiveness of D4S project efforts. Prioritisation of product stages for study will depend on a number of factors, such as whether or not the company can influence the stage and availability of information.

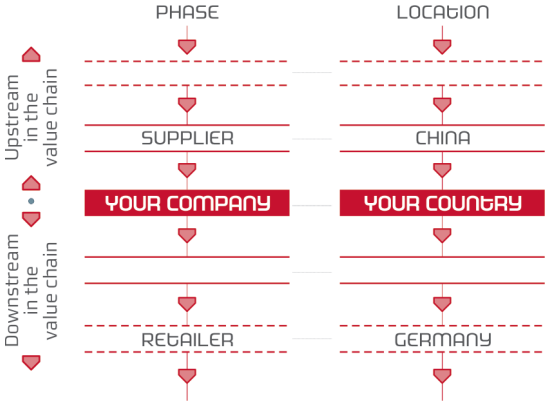


FIGURE 4-2 ___ EXAMPLE OF PART OF A LIFE CYCLE PROCESS TREE

It is useful to visualise the process tree. This can be done by using flowchart software or by sketching it by hand. It is recommended to note the physical location of each of the life-cycle stages (see Figure 4-2).

> Outline the stages of the life-cycle process tree and indicate the physical location. **> *Worksheet R5***

2> Defining the user scenario and functional unit

The product function and consumer use – known as the user scenario – can assist in defining the functional unit and should include employees, consumers, the local community, and society. The functional unit is defined as the quantified performance of a product-system and is used as a reference unit in a life-cycle assessment study.

The frequency and lifespan of product use can have significant impacts on the outcomes of the sustainability assessment, especially if the product consumes energy or materials during the use phase. It is important to take into account where the product will be used since the local circumstances, such as electricity generating source (fossil fuel, nuclear, or renewable), has a large influence on environmental impacts. The user scenario also includes the location and time-related elements of the product. For example '*the product will be used by an average family in 2005 in a large city in Europe for an average of 1 hour per day for 10 years.*'

> Define the user scenario and the functional unit of the product. **> *Worksheet R5***

3> Identify D4S impact criteria

The product life-cycle, (as discussed in Chapter 3), includes raw material acquisition, manufacturing, distribution and transportation, use, and end-of-life considerations. Each stage of the product's life-cycle consumes materials and energy (inputs) and releases wastes and emissions (outputs) into the environment (see Figure 4-3). In addition, each stage in the product life-cycle has social impacts (people) and involves economic (profit) flows.

The D4S Impact Matrix is a qualitative or semi-qualitative method that provides an overview of the environmental inputs and outputs, social aspects and profit

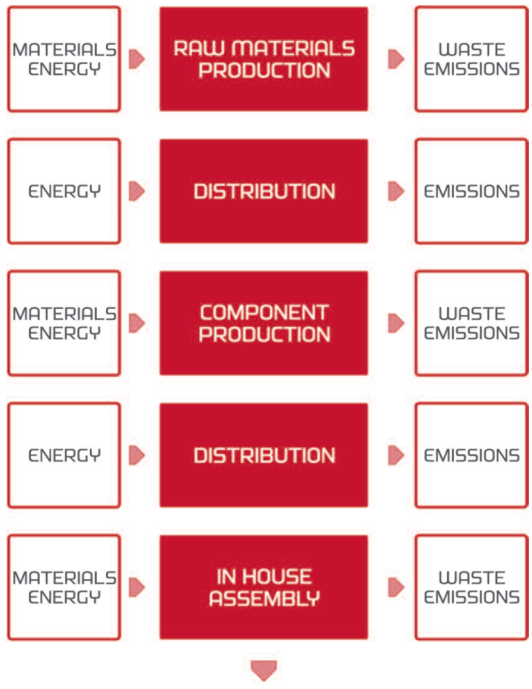


FIGURE 4-3 ___ INPUT-OUTPUT MODEL OF THE PRODUCT LIFE CYCLE

flows at each stage of the product life-cycle. It also provides an idea of where additional information is needed. It can help the team make a quick qualitative assessment of the life-cycle. The columns correspond to the different product life-cycle stages and the rows concentrate on the relevant D4S criteria.

Rows_ Environmental criteria usually include: material use, energy consumption, solid waste, and toxic emissions. Social criteria usually include social responsibility, local or regional economic development and human resource management. More issues can be considered by adding rows. Examples include issues such as specific local problems or sustainability issues like water consumption, biodiversity, CO2 emissions, cost, and cultural heritage. In addition, rows can be added and linked to the relevant D4S drivers (Steps 2 or 4).

Columns_ Depending on the *life-cycle process tree* of the product, the stages can be named in different ways and the number of columns can be increased. In Figure 4-4, the life-cycle has 6 stages. Depending on the real situation, the team can decide to add or leave out stages. For example, if a retailer is interested in the D4S impact of the products, the team might decide to add a column 'retailer' in between the distribution and use phases. In this way the contribution of the retailer (e.g. cooling of the products in the supermarket) can be made more explicit in the D4S Impact Assessment. In the case that a product leasing company is involved in the project, where the product remains the property of the leasing company, a stage 'service and maintenance' might be added.

Always try to keep the matrix clear and transparent. Do not add more columns and rows than needed!

> *Identify D4S criteria factors (rows) and life-cycle stages (columns) to be included. Complete the first row and first column of the D4S Impact Matrix.* > ***Worksheet R4***

4> Filling in the D4S Impact Matrix

The next step is to discuss and fill in the resulting D4S Impact Matrix. Often knowledge existing within the team is sufficient. The idea is to sit together and discuss the D4S aspects of the different life-cycle steps. In some cases, it might be useful to invite a D4S expert. For example, discussions of the environmental aspects might benefit from an energy expert joining the session.

There are different ways to complete the matrix. The team can select more qualitative measures (for example, plastic or fossil fuels) or quantitative measures (for example 'gasoline 200 liter'). The challenge is not to write down all the materials and processes, but to record those that are relevant.

Some suggestions for filling in the D4S Impact Matrix:

Material row_ This row is intended for notes on environmental problems concerning the input and output of materials. This row should include information and data about the use of materials and components that are: non-renewable, being depleted, creating emissions during production (such as copper, lead, and zinc), incompatible and/or inefficiently used in all stages of the product life-cycle. A few relevant questions for the team include:

> What kind and quantity of materials are used?

> Which type and quantity of surface treatment is used?

> Are they renewable or non-renewable?

FIGURE 4-4 ___ STAGES OF THE LIFE-CYCLE (E-O-L = END OF LIFE)

> Are materials incompatible (for recycling)?

> Other?

Energy use row_ This row lists energy consumption during all stages of the life-cycle. It could include energy use for the production of the product itself, transport, operating and use, or maintenance and recovery. Material inputs with high energy content are listed in the first cells of this row. Exhaust gasses produced as a result of energy uses are included in this row. A few relevant questions for the team include:

> How much energy is used during manufacture?

> What feedstock is used (coal, gas, oil, renewable, etc.)?

> How is the product transported, how far and by what mode?

> Have energy intensive materials like primary aluminum been used?

> Other?

Human resource management (HRM) row_ This row lists the activities needed to improve the company's HRM. Some relevant issues include:

> How safe and clean is the work place?

> Is healthcare being provided for employees and their families?

> Are there policies to address issues like freedom of association?

> Are there corporate policies against child labour?

> Are there corporate policies against discrimination?

> Are there training and development opportunities in place for employees?

> Other?

Similar questions apply for the other sustainability issues in the first column of the D4S Impact Matrix.

> *Fill in the D4S Impact Matrix.* > ***Worksheet R5***

5> Prioritising the D4S impacts

After completing the matrix, examine the cells and highlight those that have major 'sustainability' impacts. The next step is to prioritise the impacts which will become the focus for developing improvement options.

> *Highlight those cells or activities in the D4S Impact Matrix that have high sustainability impacts.* > ***Worksheet R5***

While developing the matrix, improvement options may become obvious.

> *Collect obvious improvement options to use in the later phase of idea generation.* > ***Worksheet R7***

STEP 6: DEVELOPING A D4S STRATEGY AND A D4S DESIGN BRIEF

The insights gained in the analysis phase (Steps 2, 4, and 5) are the starting point for Step 6. The D4S strategy wheel (see Figure 4-5) illustrates 7 general D4S strategies that cover a wide range of improvement directions and parallel the stages of the product life-cycle:

1> Selection of low-impact materials;
2> Reduction of materials usage;
3> Optimisation of production techniques;
4> Optimisation of distribution system;
5> Reduction of impact during use;
6> Optimisation of initial lifetime; and
7> Optimisation of end-of-life system.

Next to the 7 strategies described above, the D4S strategy wheel also shows the '0' strategy of a completely new product design – an important strategy in light of innovation potential. In this strategy, consumer needs define the development of a product and/or service to best meet these needs in the most sustainable manner. This chapter, which focuses on D4S Redesign, does not refer to this more radical innovation strategy. The next Chapters, 5 and 6, on radical innovation and new product development have more information on this topic.

The D4S strategy wheel, shown in Figure 4-5 can be used to define which of the design strategies are best suited for the selected product. The results of the

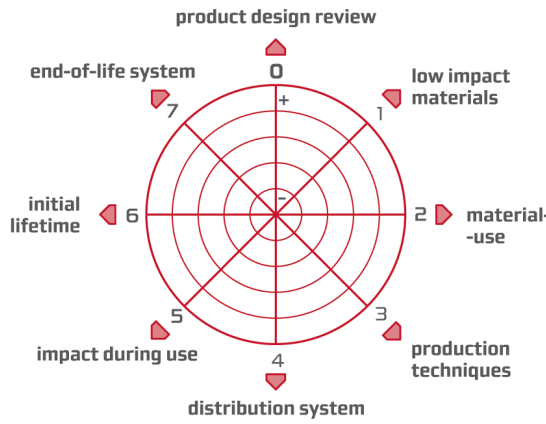


FIGURE 4-5 ___ D4S STRATEGY WHEEL

impact assessment (Step 5) are linked to potential D4S improvement strategies. However, the results from the SWOT analysis and identification of prioritised D4S drivers with the business perspective (Steps 2 and 4) may lead to a different improvement direction.

For example, in the case of an electronic product being developed by a company, the outcome of the D4S Impact Assessment in Step 5 might highlight energy use and worldwide distribution to have the greatest environmental impact. As a result, the design team could focus on D4S Strategy 5 'Reduction of impact during use' and Strategy 4 'Optimisation of distribution system'. On the other hand, the outcome from the assessment of the D4S drivers might conclude that environmental legislation regarding 'take-back' legislation and hazardous substances is essential. This outcome could lead to the decision to focus on Strategy 1 'Selection of low impact materials' and Strategy 7 'Optimisation of the end-of -life 'system'. (See Figure 4-6)

This can lead to an evaluation of trade-offs between the results of different assessments. To facilitate the decision-making process, the team can select two strategies based on the D4S Impact Assessment and two based on the D4S drivers.

> *Based upon the results of the D4S Impact Matrix, what are the 'top two' D4S strategies for improvement options? And what are the 'top two' strategies based upon the D4S drivers?* > ***Worksheet R6***

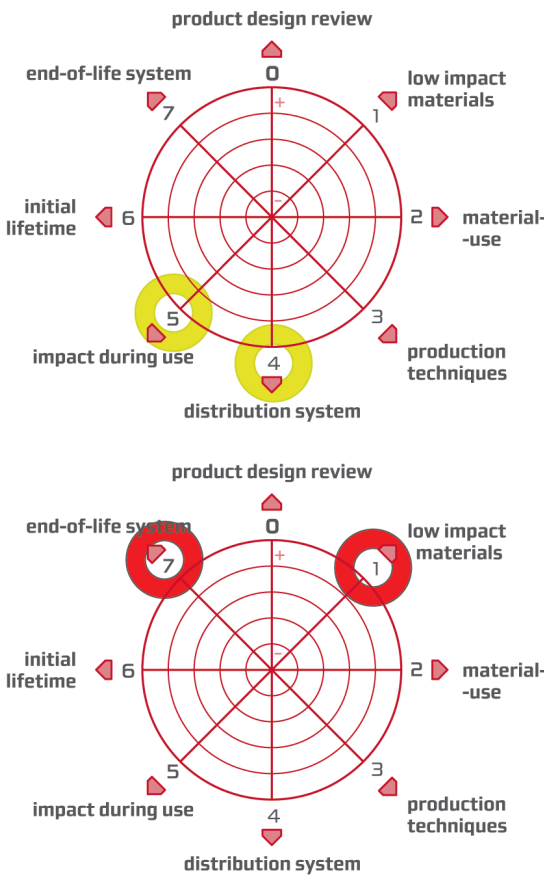


FIGURE 4-6 ___ EXAMPLE OF SELECTION OF D4S STRATEGIES BASED UPON 1) PRIORITIES OF D4S IMPACT ASSESSMENT (TOP) AND 2) PRIORITIES BASED UPON D4S DRIVES (BOTTOM)

After defining project goals and selecting 4 priority D4S strategies, the team can make a final evaluation and select the product strategies for the D4S Redesign.

> *What D4S strategies will the company and project team focus on in the next stages of idea generation and concept development?* > ***Worksheet R6***

When the guiding D4S strategies have been determined, the team can draw up a more detailed design brief. The design brief should include as a minimum:

> The reason(s) for selecting the product;
> An indication of the social (people), environmental (planet), and financial (profit) goals;
> The selected D4S strategies;
> The way the project will be managed;
> The final composition of the project team;
> A plan and time scale for the project; and
> The project budget (staff and money) and activity breakdown.

> *Work out the D4S design brief.* > ***Worksheet R6***

Case: An example of the redesign of a bottle for milk and juice products is described in the Case Studies section on the web. The company, Microplast in Costa Rica, redesigned the bottle with a focus on four strategies, low-impact materials, materials reduction, optimisation of production techniques and improved distribution.

STEP 7: IDEA GENERATION AND SELECTION

This step generates ideas for improving the sustainability of the product. Once generated, the team prioritises them and then generates, selects and details a new product concept. (See Figure 4-7)

The D4S design brief and selected D4S strategies are the starting points for generating ideas on improvement options. Different techniques can be used to generate ideas:

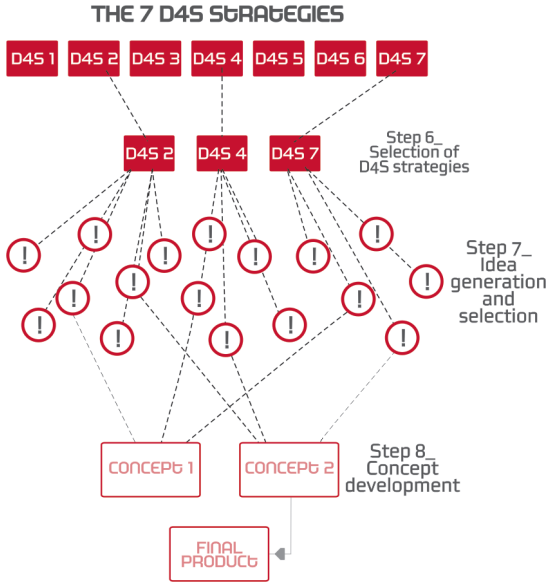


FIGURE 4-7 ___ THE D4S PRODUCT DEVELOPMENT PROCESS

1> Using the obvious ideas collected during the D4S Impact Assessment and D4S driver evaluation;
2> Using the D4S strategy wheel for brainstorming;
3> Using the D4S rules of thumb; and/or
4> Other creativity techniques.

1> Ideas from the D4S Impact Assessment and D4S drivers

During the analysis of the D4S Impact Matrix and the D4S drivers, obvious improvement options have been collected on Worksheet R7.

2> Brainstorming with the D4S strategy wheel

The D4S strategy wheel can be used to identify suitable design strategy directions as well as to stimulate the generation of new ideas. With this in mind, the 7 D4S strategies have been extended with sub-strategies, as summarised below.

1> Selection of low-impact materials that are;
a_ Cleaner
b_ Renewable
c_ Have lower energy content
d_ Recycled
e_ Recyclable
f_ Have a positive social impact, (e.g., generate local income)
2> Reduction of materials use:
a_ Weight
b_ Volume (transport)
3> Optimisation of production techniques:
a_ Alternative techniques
b_ Fewer steps
c_ Lower and cleaner energy use
d_ Less waste
e_ Fewer and cleaner materials used to support the production process
f_ Safety and cleanliness of workplace
4> Optimisation of distribution system:
a_ Less, cleaner, and reusable packaging
b_ Energy efficient transport mode
c_ Energy efficient logistics
d_ Involve local suppliers
5> Reduction of impact during use:
a_ Lower energy use
b_ Cleaner energy source
c_ Fewer consumables needed
d_ Cleaner consumables
e_ Health supporting and/or added social value
6> Optimisation of product lifetime:
a_ Reliability and durability
b_ Easier maintenance and repair
c_ Modular product structure
d_ Classic design
e_ Strong product-user relationship
f_ Involve local maintenance and service systems
7> Optimisation of end-of-life systems:
a_ Re-use of product
b_ Remanufacturing/refurbishing
c_ Recycling of materials
d_ Safer incineration
e_ Taking into consideration local (informal) collection/ recycling systems

> *Organise a brainstorming session and come up with options to improve product sustainability using selected D4S strategies.* > ***Worksheet 6***

Box 4-2 provides examples of products developed with each of these strategies. These examples aim to further illustrate the specific strategy, not to present the perfect product with an integral low score based on a complete LCA.

3> Rules of thumb for D4S strategies

'Rules of thumb' have been formulated for each of the 7 D4S strategies. An overview of these rules can be found on the web (See Module E).

> Check the D4S rules of thumb on the web to see if they stimulate other improvement options. > **Worksheet R7**

4> Apply other creativity techniques

In addition to the improvements derived from the previous steps, it also makes sense to apply other creativity techniques to generate improvement options.

'Creativity thinking' is an expression used to describe different ways of thinking that can lead to new ideas. Creativity techniques can inspire a team to generate 'crazy' ideas, but even 'crazy' ideas can lead to useful concepts. Module D on the web provides several creativity techniques.

Furniture

1. Low impact materials
Use of recycled materials.

2. Reduction of use of materials
A sitting-ball is an ergonomic office chair that uses less material then conventional office chairs.

3. Optimization of production
No glue or connection needed, because of smart connections.

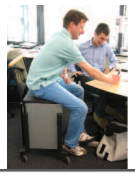
4. Distribution and packaging
The production plant of this chair is next to forest so you don't need long distance transport.

5. Decrease of impact during use phase
No leather in couch so no need to use chemical cleaning products.

6. Extension of the initial lifetime
Modular chair so you can adapt the chair to the dimensions of your child and use the chair for longer time.

7. End of life
Easy to dismantle and to recycle.

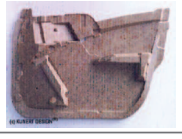
8. Other ways….to fulfill the function
A moveable office locker for flexible offices that at the same time can function as chair.



BOX 4-2 A ___ FURNITURE

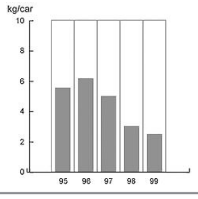
Mobility

1. Low impact materials
Natural materials as reinforcement for car doors



2. Reduction of use of materials
Aluminium body-work of audi A8, a huge reduction of weight.

3. Optimization of production
The reduction of these emissions from its production plants is a Volvo Cars priority. At the plant in Torslanda, Sweden, solvent emissions have been reduced from 30 kg per car in 1977 to today's 1,6 kg (1999).



4. Distribution and packaging
The ecological protection solution for car bodies during transport and storage.

5. Decrease of impact during use phase
Toyota Prius, hybrid car with a fuel consumption comparable with a small city car (+/- 1:21)

6. Extension of the initial lifetime
Old-timer with long lifetime and low fuel consumption.

7. End of life
Recycling of tyres.

8. Other ways….to fulfil the function
The Call-A-Bike service has been successfully implemented in several big cities in Germany. The bikes are positioned on locations in the city and the customer can easily rent a bike with a credit card and hire the bike for a certain time.

BOX 4-2 B___ MOBILITY

BOX 4-2: EXAMPLES OF APPLICATION OF D4S STRATEGIES FOR FURNITURE, MOBILITY, ELECTRONICS AND PACKAGING PRODUCTS.

Electronics

1. Low impact materials
Compared with its predecessor, the iU22 Ultrasound System weighs 22% less, eliminates **82%** of the hazardous substance mercury, reduces energy 37%, uses 20% less packaging and offers a 30% improvement in total weight of recyclable material.

2. Reduction of use of materials
The GoGear HDD 1620 Micro Jukebox uses **47%** less energy and is 12% lighter than the average of its closest competitors, and is also lead-free.

3. Optimization of production
Due to production improvements of plasma televisions, there are less screen errors during production.

4. Distribution and packaging
All flat screens can be packaged far more compactly then the conventional CRT televisions.

5. Decrease of impact during use phase
Philips Human Power Radio. Twist 30 seconds and one can listen for 25 minutes to the radio.

6. Extension of the initial lifetime
Use of LED's in traffic lights. LED's have longer lifetime then the conventional lights sources in traffic lights. The new traffic lights need therefore also less maintenance.

7. End of life
By being lighter, using less packaging and containing no lead, mercury or cadmium, this phone is much easier to recycle than those of its competitors.

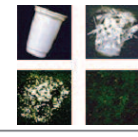
8. Other ways….to fulfil the function
One device with integrated technologies instead of several different devices. E.g. a mp3-player, camera, mobile telephone, game device and a palm-top with internet access all integrated in one communication device.

BOX 4-2 C___ ELECTRONICS

Packaging

1. Low impact materials
Biodegradable packaging, within 35 days a cup is degraded.

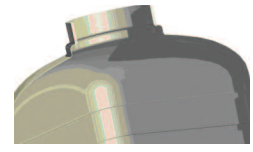
http://www.voges.nl/environment/index.html



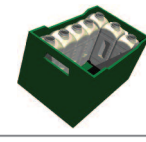
2. Reduction of use of materials
Q-CELL is inflatable packaging solution.
Q-CELL offers benefits in performance over conventional cushion protection methods, and due to it's genuine ability to be returned and re-used, substantial economic and environmental savings.

http://www.co-design.co.uk/freshair.htm

3. Optimization of production
By using a Parison Control system, it is possible to reduce the wall thickness of high pressure molding bottles. Besides less material use per bottle this also means less material reproduction during production.



4. Distribution and packaging
By redesigning the shape of the bottle (HDPE 1.8 litre) it is possible to fit 15 instead of 12 bottles in a standard distribution crate.



5. Decrease of impact during use phase.
This glue is water-based and uses easy-to-recycle packaging. Also, production does not use heat during the sealing process, leading to a drastic reduction of energy use.

http://ecobliss.com/english/1-about/1a02-environmental.html

6. Extension of the initial lifetime
By packaging mustard in a drinking glass, the packaging gets a new function after the mustard is consumed.

7. End of life
Fleece clothing made from recycled PET.

8. Other ways….to fulfil the function.
Returnable packaging.

BOX 4-2 D___ PACKAGING

> *Organise a creativity session and generate improvement options.* > ***Worksheet R7***

Selection of promising ideas

After generating a lot of ideas, it is useful to cluster them according to the seven D4S strategies.

> *Cluster all the generated improvement options according to the D4S strategies.* > ***Worksheet R7***

A qualitative process of selection is then applied to prioritise the ideas. The improvement options are subsequently assessed for environmental, social, and economical impact/benefits as well as technical and organisational feasibility. In addition to the criteria below, each company may define additional parameters or weigh them differently according to individual circumstances.

Possible criteria could be:

> Expected environmental (planet) benefit;
> Expected social (people) benefit;
> Expected economical (profit) benefit;
> Technical feasibility (given resources available to the company);
> Organisational feasibility;
> Perceived added value to the customer; and
> Market potential.

> *Which criteria should be used to select and prioritise improvement options?* > ***Worksheet R7***

The improvement options can be evaluated and weighed according to each criteria (See Figure 4-8).

The feasibility of various options is often time-related: some improvement options and redesigns can be carried out immediately (short-term) and others require more time (mid- or long-term).

> *List the options and rate each one based on the time implications (short or long-term).* > ***Worksheet R7***

A final choice can usually be made only after the ideas have been fleshed out in greater detail. This process is known as a 'product concept'.

++ 2	Very positive score/ very feasible
+ 1	Positive score/ feasible
0 0	Neutral score
- -1	Negative score/ almost feasible
-- -2	Very negative score/ completely infeasible

FIGURE 4-8

STEP 8: CONCEPT DEVELOPMENT

In this step, the selected product ideas are developed into concepts and then into a more detailed design. In essence, the ideas generated previously are combined into holistic concepts. (See Figure 4-9)

At this stage there will be some uncertainty about the feasibility of various ideas. In practice, several concepts will be developed at the same time. It may be possible to combine several concepts into one design. A technique called the 'Morphological Box' (See Module D 'Creativity Techniques' on the web) is valuable when the team wants to combine several ideas in one product concept in a systematic way. (See Figure 4-9.)

Various tools are available for the D4S Redesign team to evaluate technological feasibility and optimise the design process, including test models, prototypes, and computer simulations. Attention to the financial feasibility of the new concepts is necessary. The project team will have to ascertain whether the financial benefits of the options will outweigh the costs involved.

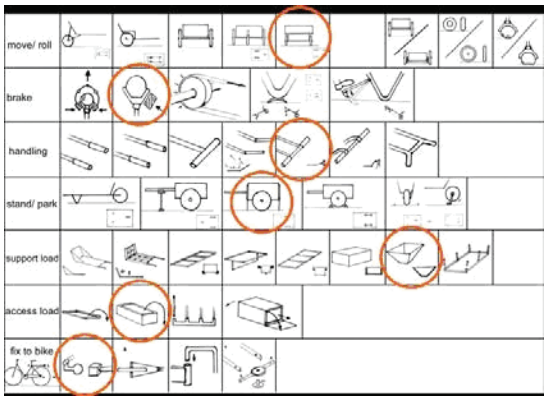


FIGURE 4-9 ___ MORPHOLOGICAL BOX FOR A FOOD TRAILER IN GHANA (UNEP 2006)

It can be useful to evaluate concepts by using the information in the product specification from earlier steps (like the D4S Design Brief), and assigning qualitative values such as good, fair, poor, or numerical scores from 1 to 10. Using these values, an overall value can be given to each of the concepts. This process may be similar to the one applied during the idea generation and selection stage (Step 7).

In addition to concept development, the production plan and marketing plan are developed during this stage, as in traditional product innovation projects.

STEP 9: D4S EVALUATION

Comparing the product profile of the new design with that of the previous product enables an estimate of the sustainability merits of the new product. Efforts should be made to be as quantitative as possible when evaluating the redesigned product.

> Evaluate the benefits of the D4S drivers and goals as defined in Step 2. ***> Worksheet R9***

STEP 10: IMPLEMENTATION AND FOLLOW-UP

This step involves integration of sustainability elements into prototype production, testing, planning of large-scale manufacturing, and test marketing. During prototyping and testing the actual sustainability performance of the product can be evaluated for the first time. In the test marketing, consumer reactions to the sustainability qualities of the products can be assessed along side standard criteria. With these insights, final alterations can be made before large-scale market introduction. Key stakeholders identified in the initial phase may also be taken into account.

In parallel, the company needs to prepare a communication strategy. The company can decide to present the sustainability benefits of the product explicitly in its advertisements or not. Both strategies have advantages and disadvantages. Explicit marketing can be worthwhile if the consumer group is interested in sustainability issues, or when the marketing contributes to a brand or corporate image. The disadvantage can be that the company may be required to substantiate its sustainability claims.

See Module G for a detailed discussion of D4S Communication.

After the product launch, the company can monitor the product's sustainability performance. Consumer feedback, as well as information derived from internal product testing can be incorporated into the planning process for further product revision.

See Module F for a detailed description on D4S Management.

A good example of an ongoing programme of product improvement is Philips' 'Green Flagship' programme (Box 4-2)

BOX 4-2: Philips Green Flagships, The Netherlands

Company & Stakeholders

Building on Philips' tradition of innovation and technological expertise, Philips has developed procedures for Environmentally Conscious Product Design –EcoDesign – that deal with all phases of product development. To support the EcoDesign process, Philips' EcoVision programme focuses on the following Green Focal Areas during product developing:

Energy consumption | Packaging | Hazardous substances | Weight | Recycling and disposal | Lifetime reliability

These focal areas were introduced as part of the first EcoVision programme in 1998. Over the years Philips has realised there is a need for customisation to reflect areas of particular relevance for their businesses. Energy efficiency for Lighting division products is expressed in efficacy, which is the amount of visible light produced (lumen) per Watt (lm/W). For other products, energy use is expressed as kilowatt-hours per year (kWh/year), based on average annual use. Packaging reduction and the resulting savings in transport and logistics is an area of particular concern for Consumer Electronics, driven by cost and environmental considerations. To deal with this challenge, Consumer Electronics is focusing on reducing packaging volume and adapting pack-

aging dimensions to increase shipping efficiency by being able to load more products in a single container. This is in addition to work being done to reduce packaging weight.

Green Flagships

The top EcoDesigned products achieve Green Flagship status. This means that after going through divisional EcoDesign procedures, a product or product family must be investigated in three or more of the Green Focal Areas and proven to offer better environmental performance in two or more of those areas, compared with its predecessors or closest commercial competitors.

When a product is compared with more than one competitor, the results are expressed as an improvement compared to the average of the competitors' performance in the investigated focal areas. To continue to drive innovation and the development of environmentally responsible products, the current EcoVision programme calls for one Green Flagship product per product division each year. In 2004 four product divisions fulfilled their commitment to developing at least one Green Flagship per year and a total of 21 were put on the market. The following two products are examples:

Figure 4-10 **iU22 ultrasound system, from Philips Medical Systems**

Results

With its intelligent control and advanced ergonomic design, the iU22 ultrasound system (see Figure 4-10) delivers a range of high-performance features, including next generation, real-time 4D imaging, voice-activated control and annotation, and automated image optimisation technologies. Compared with its predecessor, the iU22 weighs 22% less, eliminates 82% of the hazardous substance mercury, reduces energy use by 37%, uses 20% less packaging and contains 30% more recyclable material by weight.

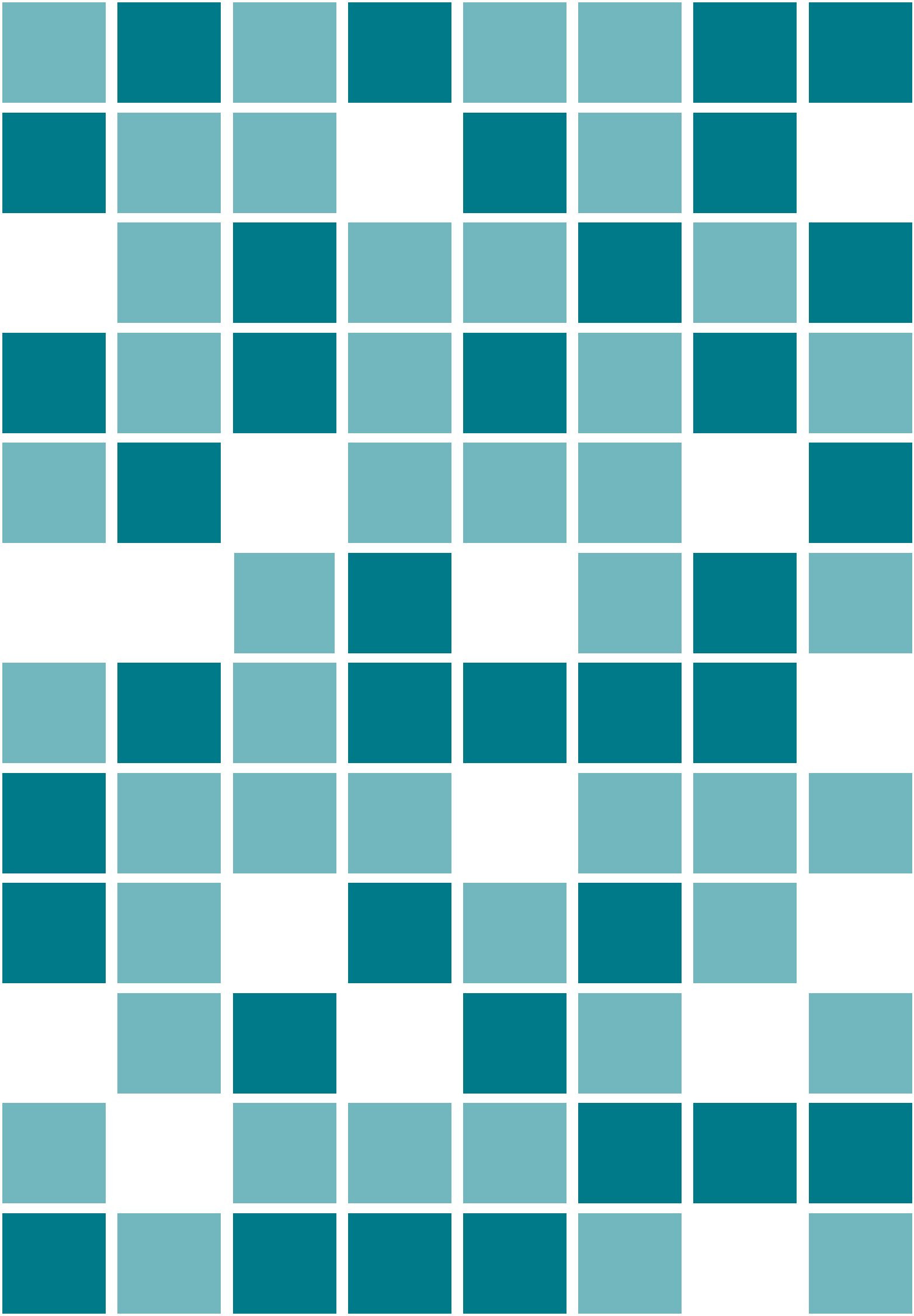
Figure 4-11 **DECT 525 Telephone, Philips Consumer Products**

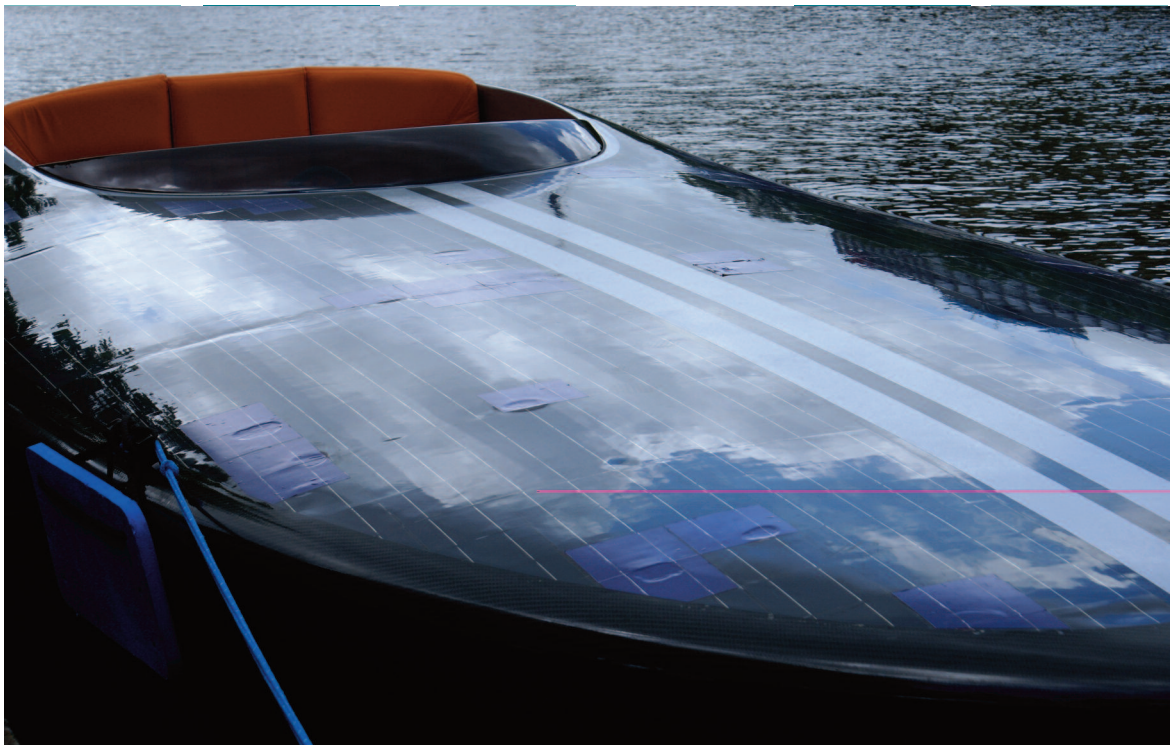
Results

The DECT 525 (see Figure 4-11) maintains the high quality sound and easy to use features consumers expects, while consuming 54% less energy and using 14% less packaging than the average commercial competitor. It also uses 33% less raw material and improves recycling and disposal 12%. Cadmium, lead, and mercury have been eliminated from this phone.

(source: www.sustainability.philips.com , Sustainability Report 2004 Royal Philips, Sustainability Report 2005 Royal Philips)

In this chapter, the D4S approach for redesigning an existing product has been explained. This is a practical way to start implementing the D4S concepts in a company. The overall improvements in sustainability that are typically made with this approach are a good start, but usually not enough to achieve the long-term levels of environmental and societal sustainability that are needed. For this, more radical sustainable product innovation is necessary. These strategies are discussed in the next chapters.





PROFIt

05

OUT-OF-THE-BOX: RADICAL SUSTAINABLE PRODUCT INNOVATION

MARCEL CRUL AND JAN CAREL DIEHL

The incremental innovation approaches of redesign are not enough to achieve long-term sustainable development. Out-of-the-box, or radical, innovation strategies on the other hand can lead to more sustainable impacts while providing the breakthroughs necessary to ensure industries' continued growth.
This chapter outlines the benefits of radical innovation and the need for more of these initiatives. It should be noted that radical innovation differs significantly from incremental innovation in that it involves more risk. However, this chapter provides a number of tools proven to effectively manage and minimise these risks.
This chapter serves as an introduction to Chapters 6 and 7, in which the specific methodologies for radical product innovation are described. Chapter 6 deals with new products and system innovation and Chapter 7 with Product-Service Systems.

5.1 THE NEED FOR RADICAL SUSTAINABLE INNOVATION

Previous chapters in this publication have outlined the process for improving an existing product.

While these strategies are effective for initiating D4S projects and beginning to address sustainability challenges, more drastic approaches are needed to achieve a long-term balance between the economic, environmental, and social pillars of sustainable development. Radical sustainable product innovation, including breakthroughs and leapfrogging, is required to reach the desired improvement factor of 10-20 (incremental redesign only yields improvement factors of 2-3). Refer back to Chapter 2 Section 2.5.2 - Improvement Factors for a review on factor thinking of D4S. This chapter details the principles of radical product innovation and provides examples of higher product-system sustainability.

The effectiveness of Product-Service Systems (PSS) is dependent on 3 factors: the design of the product, the design of the service, and the system in which the product-service combination functions. The system itself is characterised by (1) the organisation or business that runs the service or activity-chain and by (2) the selected infrastructure.

Successful and sustainable PSS are designed so that the system has value for the end-user and is profitable for other actors in the chain. Optimising the use of existing infrastructure, such as buildings, roads, and telecommunications networks, will lower investment costs and increase potentials gains.

While most PSS are developed using existing or slightly redesigned products (see Box 5-1), ideally entirely new products would be developed to create superior sustainability solutions. Use of existing products provides designers with expediency to better compete with other services in a highly competitive market, but it also limits the sustainability gains that can be made. While the development of new products can be challenging and as complex as setting up a new business or venture, the rewards are significant.

Research in the radical product innovation field is still in the early stages but initial studies have yielded valuable insight into the project implementation process. This insight is detailed in following sections however it is important to note that the approach should be tailored to fit the selected product and implementing company or organisation.

BOX 5-1 More and more responsible business actors and service designers are incorporating existing products into their services, for example,

many green car renting companies select their vehicle fleet by evaluating fuel usage and integrating innovative Information and Communication Technology (ICT) based renting and reservation systems. Additionally, Dutch Railways combined the train reduction card with a bicycle renting card. Under this system, passengers can rent a bicycle at any train station within less than 30 seconds for only €2.75. This combination makes renting bicycles convenient and affordable.

5.2 MANAGING RADICAL PRODUCT INNOVATION

There is abundant existing research on product innovation management (see references section for additional reading). An underlying theme of the existing research is the importance of product innovation managers drawing upon the lessons learned from successfully implemented radical innovation projects. A few of the main lessons from radical product innovation are summarised below.

In today's literature a distinction is usually made between two types of radical innovation, new-to-the market and breakthrough. In this context, radical refers to product innovations that have the potential to disrupt existing industries and are able to create new businesses, services, consumer behavior, and infrastructures.

> New-to-the-Market: Novel substitutes, based on products that are new to society; and

> Breakthrough: Significantly changes the existing industry or creates a new business.

The are several variables that contribute to the achievement of radical product innovation. First, is the vision of the innovator or innovative organisation. Second, is the ability to develop new and emerging technologies that are not easily replicable. Thirdly, the use of management tools to streamline the radical innovation process. In summary, radical product innovation is a function of vision, technology and management.

The risks associated with radical innovation are significantly higher than those of traditional business innovation. It is more volatile, the outcomes less certain, and the time horizon tends to be much longer. In many cases, existing companies are not able to create new-to-the-market or breakthrough solutions because of the high risks associated with these strategies.

The Ansoff Growth Matrix is a tool that can help companies evaluate growth strategies and analyse risk. As shown in Figure 5-1 when new products and new markets are developed simultaneously, companies are assuming a greater level of risk. There are three types of diversification, first, companies can seek new products that have technological and marketing synergies with existing product lines, in which case the resulting product may appeal to a new class of customers. Second, companies can search for new projects that are technologically unrelated to the existing product line that possess market demand with their current customers. Finally, companies can seek new businesses that have no relationship to the company's current technology, products, or markets.

FIGURE 5-1 ___ ANSOFF GROWTH MATRIX

NEW COALITIONS

In most cases radical product innovation requires a new venture or the support of external partners to provide additional competencies and capabilities. When additional expertise is required, companies should form a new coalition with external partners to support implementation efforts. This outside support can be in the field of design creativity, complementary technologies and markets, production facilities, etc. In finding the right partners, it is important to avoid conflicts of interest and to strive for a win-win situation with an attractive cost-benefit ratio for coalition partners. The formulation of new coalitions can be a difficult process as the necessary trust building requires time and working effectively together requires flexibility. The progress of radical undertakings can be hindered by obstacles such as a breach in confidentiality or overlapping markets among coalition partners which may lead to excessive competition.

NEW VENTURES

If radical product development is not feasible within the existing company structure, one alternative is to create a new business venture. If the new business is linked to the existing company a certain element of 'intrapreneurship', is required, if it is created separate from the company, venture capital and entrepreneurship may be in store.

Developing a new business venture outside the existing company is often the best option for entrepreneurs in radical product innovation as new activities are often met with resistance within an organisation when the idea (1) goes beyond the demands of environmental or social legislation; and (2) posses significant risk.

Anyone with a challenging idea - be it inventor, artist, or manager - can start a radical undertaking. Numerous programmes supported by chambers of commerce, innovation agencies, financial institutions, and government agencies exist to support the new entrepreneur. In addition, many universities around the world facilitate the creation of these new ventures as their environments provide students and other academic entrepreneurs with the support (in the way of infrastructure and entrepreneurial expertise) necessary to establish university spin-off businesses.

A number of sustainable innovations originate from university spin-offs, this is due to the supportive environment for innovations and because the younger generation tends to be more open to new ideas and technologies. Examples of university spin-offs from the Delft University of Technology include the Epyon, an efficient battery charging system in which the charge time is reduced to minutes instead of hours. The Epyon system is designed for the batteries of vehicles and mobile products. The Senz umbrella, a windproof umbrella (up to a wind force of 10) that is more resistant to inversion (less destructible and more resilient). These umbrellas are more durable and have a much longer lifetime. The Evening Breeze, an air-conditioned bed which if used to replace traditional cooling systems can save 60 percent on the hotel room's energy consumption (see Figure 5-2).

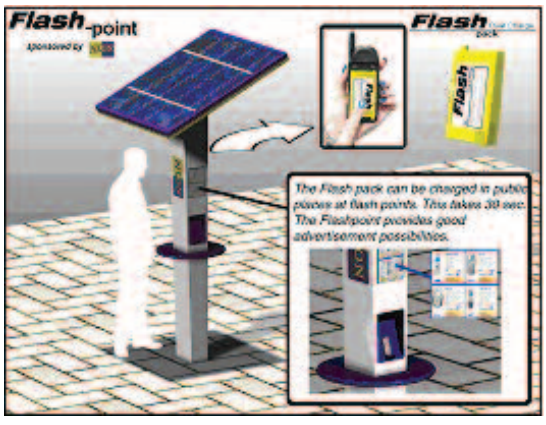


FIGURE 5-2 ___ EXAMPLES OF SUSTAINABLE PRODUCTS FROM UNIVERSITY START-UP COMPANIES IN DELFT UNIVERSITY OF TECHNOLOGY: PREVIOUS PAGE TOP: FAST CHARGER FORM EPYON,, PREVIOUS PAGE BOTTOM: INNOVATIVE UMBRELLA FROM SENZ UMBRELLAS, AND ABOVE: INNOVATIVE AIR-CONDITIONED BED WHICH SAVES ON HOTEL ENERGY USE.

5.3 METHODS AND TOOLS FOR RISK REDUCTION

THE INNOVATION FUNNEL*

There are a variety of methods and tools available to assist managers in reducing the risk involved in radical product design. The 'innovation funnel' is a common approach among larger research and development driven companies. The 'innovation funnel' can be viewed as a stage-based approach to innovation. (See Figure 5-3)

As shown in Figure 5-3, the 'innovation funnel' is comprised of 4 stages. The stages are (1) problem orientation and strategy; (2) idea generation and design; (3) demonstration and launch investment; and (4) production, roll-out, and exploitation.

The tollgates I, II, and III are the points in the funnel where key decisions are made. Options at each of the tollgates are as follows:

> *Continue to the next stage*: for instance when all goals are positively met;

> *Move the project from 'out-of-the-box' to 'inside-the-box'*: for instance when profitable opportunities for the innovation emerge at existing markets, the innovation project could be fitted in the existing business portfolio;

> *Stop the project:* for instance when the idea seems not to be able to make money or – on the contrary – is very good, but doesn't seem to fit the company profile.

Box 5-2 provides a number of relevant guidelines for managers using the innovation funnel.

Box 5-2
Guidelines for managing the innovation funnel

1- The funnel needs to be loaded with innovations at all stages
2- Projects have to move forward through the funnel as in a supply chain
3- The stages are sequential and interdependent
4- Each stage and tollgate has to be managed separately

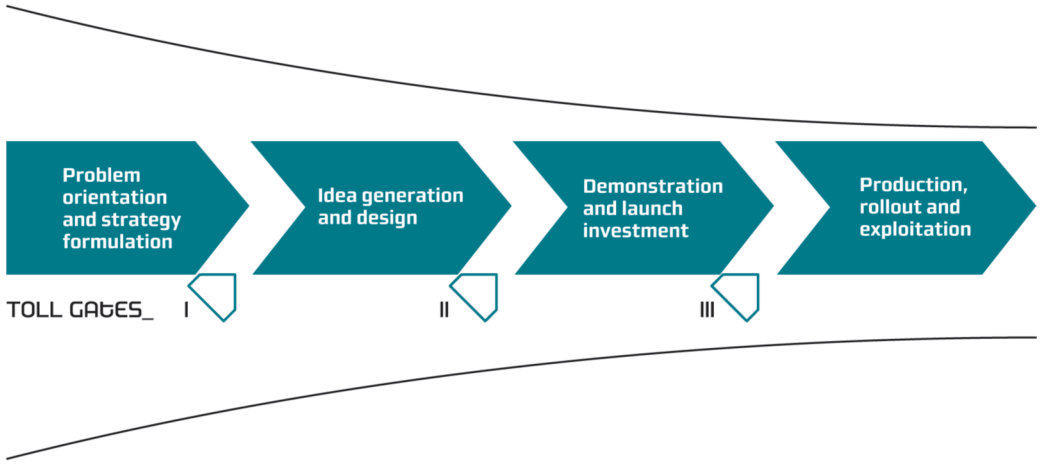


FIGURE 5-3 ___ INNOVATION FUNNEL

* Parts of this section are - with permission - directly cited or adapted from: Verloop 2004 (see references)

5- Each stage and the overall process can be optimised with respect to resource use and reaching the objectives
6- Clear guidelines and criteria should be in place at each tollgate and all actors should understand and be in agreement
7- Each consequent tollgate requires the same criteria, but with an increasing demand for detail and quantification
8- Tollgate III requires a comprehensive and detailed business and launch plan
9- The innovation manager is responsible for keeping the momentum, managing the tollgates and optimising the supply chain
10- The innovation manager is responsible for the link with the innovation strategy, the identification of stakeholders, and balancing efforts –i.e. between 'bottom-up' and 'top-down' and the position of the radical innovation team

BRICOLAGE

Bricolage is another tool used to minimise the risk involved in radical product development. Berchicci underlines the additional difficulties an entrepreneur might encounter when trying to achieve highly ambitious sustainable goals by radical product innovation. Berchicci stresses the need for a step-by-step or bricolage approach, even in cases where the environmental ambition is high. Bricolage involves starting with small actions, with regular feedback loops from potential future users to maximise the use of experiment and trial-and-error. In this case, goal setting may emerge in the second stage, instead of at the onset of a radical undertaking. Berchicci encourages environmentally driven designers to integrate flexibility into their vision and innovation process to develop breakthrough products. This approach posits that the best way to build up capabilities and simultaneously decrease uncertainty is to conduct simple tests, or pilots. Therefore, radical sustainable product innovation is best achieved through a series of incremental innovations as the integration of a number of smaller solutions can produce significant results while reducing risks and failure. The Bricolage approach is recommended for SMEs and new ventures with limited research and development budgets.

CASE The case on new mobility concepts provided in the Case Study section on the web describes an example of a bricolage approach in radical D4S innovation. Starting from the 'MITKA' project, several others concepts for sustainable new mobility were developed.

5.4 CREATIVE INDUSTRY AND DISTRIBUTED ECONOMIES

In addition to models on product and business innovation, a new paradigm has recently emerged stressing the importance of cities as facilitators of societal innovation. Richard Florida is the main representative of this paradigm. His book 'The Rise of the Creative Class' further details this concept (see references at the end of this publication). The main points are outlined below:

> Technology is a partial collection of a much broader class of activities, called 'creativity'

> Technological creativity – our capability to invent new products and processes is crucial, for a successful economy

> Other creativity, such as aesthetic, stylistic, cultural, artistic and musical, is also necessary for successful commercial entrepreneurship

> Supporting the creative class with an attractive, active and inspiring infrastructure and synergy of the different creative variables in all societal sectors is a precondition for successful innovation.

In Florida's theory, cities and particular neighbourhoods have become the central organising factor.

However, this model does not explicitly address sustainable development. Therefore, other models complement the creative class paradigm with the concept of Distributed Economies (DE). They argue that growth, which is dominantly driven by production efficiency, is accompanied by the dynamics that undermine sustainability. To address this concern, the authors introduced DE, which advocates to decentralise a portion of production activities and distribute them throughout the region in the form of small-scale, flexible, and synergistically interconnected production units. DE serves to establish a renewed balance between small and large-scale production units and the three pillars of sustainability.

Environmental and social principles guide the development of DE according to the following criteria:

> Increasing the share of *renewable resources* in economic activities;

> Increasing *wealth creation* for a larger number of people;

> Decreasing *pollutant emissions* and *waste generation* at the local and regional level

> Increasing the *sustainable use of local resources* in economic activities

> Increasing the *value added to local resources*

> Increasing the share of *added value benefits retained* in the regions

> Increasing the share of *non-material* (e.g. information know-how) and *higher added value* material resources in cross-boundary resource flows

> Increasing the *diversity and flexibility* of economic activities

> Increasing the *diversity and intensity of communication and collaboration* among regional activities

The DE criteria are in line with the D4S concept.

5.5 SUSTAINABILITY AND RADICAL PRODUCT INNOVATION

In addition to technology and business, sustainable development has become an independent driver for change. While today's policies seem restricted to the regulation of the proper end-of-life management of certain product groups, in the future – as factor X thinking objectives (refer to Chapter 2 Section 2.5.2 for a review of factor X thinking) for product-systems become more accepted global standards- value creation will move beyond end-of-life management to include societal concerns throughout the value chain. As found in sustainable innovation literature: 'Sustainable innovation has three value drivers – technology, business and society – that need to be in balance to create new choices for the customers of today, without compromising the options for the future.

In the value driven model, the cycle for D4S sustainable innovation begins when society starts to adopt or develop new values and to reject certain products in the market place. At the same time, technologies emerge to support the creation of new Product-Service Systems that fit the new values. Sustainability becomes a social change driver, complementary to marketing pull and technology push.

In practice, ongoing efforts are being made to operationalise these concepts, taking both the lessons from product and business innovation, creative cities, PSS (Chapter 7) and design oriented scenarios (Module B and C on the web) into account.

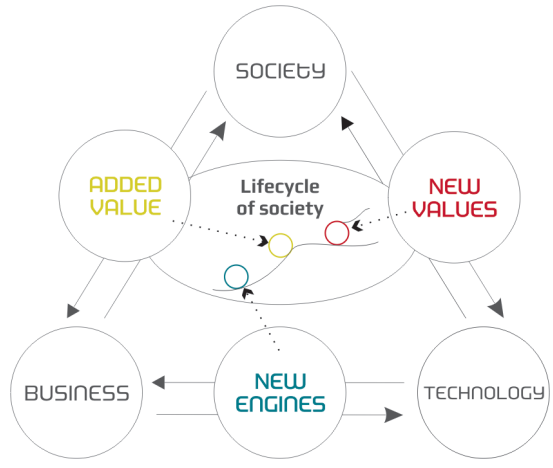


FIGURE 5-4 ___ THE VALUE DRIVEN MODEL FOR SUSTAINABLE INNOVATION (VERLOOP 2005).

06 NEW PRODUCT DEVELOPMENT

JAN CAREL DIEHL

New product development is a method of out-of-the-box innovation which involves a higher level of technical, market, and organisational uncertainty than redesign, as discussed in Chapter 4. Given the increased uncertainty of the new product development process, no standard rules of thumb to improve an existing product can be applied, and a more open 'idea finding' phase is necessary. In this chapter, a general model for new product development for D4S is explained and several new product technologies and market opportunities are described. Additionally, the strong connection between system innovation and new product development is examined.

6.1 PRODUCT INNOVATION

As introduced in Section 2.7, new product development follows the four basic stages of product innovation (policy formulation, idea finding, strict development, and realisation) and involves a series of sub-processes dominated by the product development process followed by the realisation of project activities (see Figure 6-1).

Product Innovation = Product Development + Realisation

Product development can be defined as 'the process that transforms technical ideas or market needs and opportunities into a new product and on to the market.' It includes strategy, organisation, concept generation, product, and marketing plan creation and evaluation, and the commercialisation of a new product.

The product development process is a creative and iterative set of steps and phases that converts ideas into saleable products and/or services. The product development process itself can be split up into three phases:

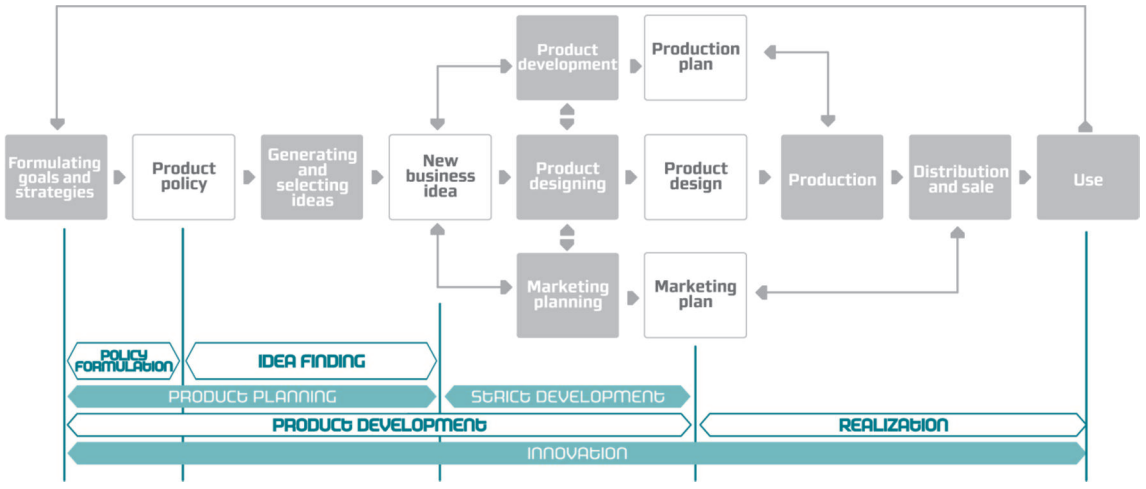


FIGURE 6-1 ___ PRODUCT DEVELOPMENT AS PART OF THE PRODUCT INNOVATION PROCESS

policy formulation, idea finding, and strict development (see Figure 6-1).

Each step contains a divergent activity that identifies relevant information in a creative way and a convergent activity which evaluates that information (see Figure 6-2). The divergent activity explores and redefines problems, generates ideas, and combines concepts. The convergent activity imposes value judgments and includes methods to make sense of information, prioritise items, compare solutions, assess ideas and select concepts. The product development process is often presented as a linear process. However, in practice it can contain iterative cycles, where design teams go back to earlier stages in the product development process to re-evaluate decisions that have been made.

Development of new D4S products is not an isolated process. Production development and marketing planning take place in parallel to the product development process (see Figure 6-1). Since production development and design are directly linked, equipment availability and investment needs should be considered during the design phase. Production management will need to address how to introduce any production changes resulting from design changes. In addition, information on market analysis, consumer behaviour, trends and future scenarios, government policies, environmental concerns, new technologies and materials is essential for targeting a new product to the needs of consumers.

In contrast to redesign, there are no clear rules-of-thumb or strategies to be followed for new D4S products, since the approach exactly is focused on new products for existing or new markets. Hence, the more open 'idea finding' phase is included in the stepwise approach explained above. In Module D several forms of creativity techniques are presented that can support in this. Also, the approach of design-oriented scenarios in Module B can provide new ideas and concepts.

Another source for new product ideas come from new product technologies and the vast array of new opportunities they can provide – as highlighted in the next section.

6.2 NEW PRODUCT TECHNOLOGIES

New product technologies such as eco-materials, nanotechnology, renewable energy sources, and Information and Communication Technology (ICT) can be a source of inspiration for new product development, since these technologies often add value when incorporated into a new product. Incentives of these technologies include increased savings through energy and resource efficiency, reduced toxicity, and improved reusability or recyclability. Additional information on these technologies is provided below.

> Eco-materials are new materials that have far less impact on the environment and play an important role in new product developments. Eco-materials are characterised by one or more of the following attributes: increased savings in energy and/or resources, improved reusability or recyclability. Module H provides additional information on these materials.

> Nanotechnology is a growing field that offers great innovation potential in the realm of sustainable materials (smaller, lighter, and more intelligent). A downside of this technology is that the byproducts generated in the processing are not well researched and could possibly

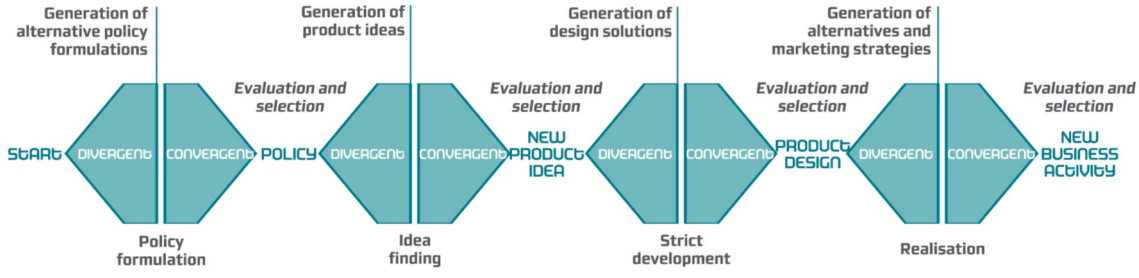


FIGURE 6-2 ___ STEP-BY-STEP DESIGN APPROACH CHARACTERISED DIVERGENT AND CONVERGENT ACTIVITIES.

be toxic. The potential applications for nanotechnology lie primarily in the car and electronics industries, for example non-scratch windows, self-repairing structures, etc.

> Renewable energy sources, such as human powered devices and photovoltaics offer great sustainable enhancement potential for portable products, one example being larger distribution of medical care instruments in remote regions. Fuel cells can add to this potential, provided their energy sources are from a sustainable source. Section 6.3 provides a number of options for the integration of renewable energy sources into consumer products. Additional information on renewable energy options in technical product innovation can be found in Module I.

> ICT easily contributes to new product development by advancing sustainable functionalities or features in existing products. Intelligent products can be developed to reduce energy use, improve connectivity and improve functionality. Multifunctional products reduce the need for separate products for example, camera-phones. ICT can also provide new opportunities for learning tools such as in the example of 'One Laptop per Child' (refer to Section 6.4). More examples of ICT contributions to new D4S products can be found in Module J on the web.

6.3 Integrating Human Powered, Photovoltaics and Fuel Cell Energy Systems into Consumer Products

The application of Renewable Energy (RE) technologies like Human Power (HP), Photo Voltaic (PV) cells, and Fuel Cells (FC) offer more sustainable alternatives to current energy systems. The integration of these new energy technologies into D4S product design is moving from the experimental phase towards becoming an established discipline in Industrial Design. To continue the forward momentum of these design efforts, it is necessary to increase the amount of structural information regarding the identification and integration of renewable energy technologies into products available to technological developers as well as industrial designers.

Each of the three RE technologies listed above have their own advantages and disadvantages for product and product-system applications. The added value of RE technology is contingent upon product applications and design limitations. Table 6-1 outlines the potential advantages of HP, PV, and FC.

PV-Powered Product-Systems

Of the three Renewable Energy technologies listed above, the PV-cells are currently the most applied at the product and product-system level. During the last decade the number of PV-cell product applications has significantly increased. A wide variety of electronic products are powered by PV-cells, including solar chargers, outdoor lighting, calculators, gadgets, ticket machines, etc. These can be characterised into one of the following four groups of PV products.

1. Existing product designs with an 'added' PV source:

There are a variety of existing products in which PV cells have been included as an alterative energy source. For example, the PV-powered weight-scale shown in Figure 6-3 has 'pasted' PV cells onto the product by adding an additional surface. The PV-cells are not integrated into the product's design and do not create an essential added value for users (the battery normally only has to be replaced once every 3 years).

2. Redesign of existing products with 'integrated' PV source:

If PV-cells replace another type of energy source in a product, it is very likely that the product design and the configuration were adapted and optimised for the new situation. While integration of PV-cells into the product's design can enhance its sustainability, the design must take into account product function or the innovation effort may not yield the intended benefits. Take for example, the solar battery pack for a mobile telephone (shown in Figure 6-3). In this example the solar cells have been integrated into the product using transparent plastic and hi-tech surface styling, despite constrains in the size and shape of the battery pack. While the intended value of this product–technology combination is clear, there is not a suitable balance

Potential advantages	HP	PV	FC
No or low CO2, NOx and SOx emissions - environmental sound technology			
No or low noise			
No moving parts			
Stand alone systems (decentralized and independent generation from electricity grid)			
High power range products (> 2 KW)			
Medium power range products (100 to 2000 W)			
Low power range products (0 to 100 W)			
Wireless systems			
Minimal maintenance requirements			
Use of batteries for storage			
Can replace batteries in products			
Long life time of the working system (> 20 years)			
Use of renewable sources			
Possibility to use several types of sources (including non- and renewable)			
System affected with specific external conditions (for example specific geographical or weather conditions)			
Higher energy density than conventional rechargeable batteries			
Faster source storage (few minutes)			
Unlimited refuelling cycles			
Longer shelf life (compared with common batteries)			
Off - grid systems			
Possible to integrated with the grid system			
Convenience for the user by not replacing batteries			
Interaction between the product and the user			
Potential disadvantages			
Long pay back time			
Limited energy power output			
Conflict with the use of the product can happen			
Large area needed for large power applications			
Inverter or special DC appliances needed to convert DC in AC, when it is needed			
Possible to use as storage energy			
Need for a sustainable fuel (production and distribution) infrastructure			
Non dangers storage of sources or fuel			

TABLE 6-1 ___ CHARACTERISTICS OF HP, PV AND FC

between energy generation and consumption. Although the PV-cell area is small, a full day of sun would be required to supply the energy required to maintain proper functioning of the mobile telephone. However, the mobile telephone will often be disconnected from sunlight because it will be in the palm of the hand when in use and is often carried inside a bag or a pocket. The characteristics and positioning of PV-cells do not provide an optimal match with the user context and energy need.

3. New products based on PV technologies;

Based upon the characteristics of the new RE technologies and consumer needs, new PV-powered products are increasingly being developed. For example, solar chargers offer consumers the distinct advantage of generating energy independent from batteries or the electricity grid (refer to Figure 6-3). The design should be developed considering the new function and technology, the shape and colour should be matched to user preferences, and there should be a suitable match between energy generation and consumption.

4. New product-systems based upon PV technologies;

Low voltage and Direct Current (DC) appliances are rapidly being introduced in today's market, for example, mobile telephones, ipods, and personal digital assistants (PDAs). In order to power these products the 220 Alternating Current (AC) has to be converted twice to the low-voltage DC. This process results in efficiency losses. Renewable Energy technology like PV-panels produce low voltage DC electricity which makes them (more) compatible to power these appliances. One of the current solutions under research is to integrate a PV-powered low voltage DC electricity grid in houses to power these products more efficient and to abandon the need for adaptors

> Case: The development of a new PV powered lantern for the Cambodian market is described in detail in the Case Study section on the web.

HUMAN POWERED PRODUCTS

While human-powered products are not a new concept, they do offer great advances in product sustainability. The introduction of the Freeplay radio in 1996 sparked interest in fusing HP and products and as a result a range of HP products have been introduced into the market (see Figure 6-4). In the first example, a Freeplay wind-up flashlight is equipped with a metal spring to store energy. While the HP innovation adds value, one might question if the bulky weight and dimensions do not present an inconvenience to users. In the second example, the HP technology has been integrated more sophisticatedly into the product (by shaking the flashlight, linear induction within the light creates energy). Finally several new HP-products have been developed to charge low power products like mobile telephones.

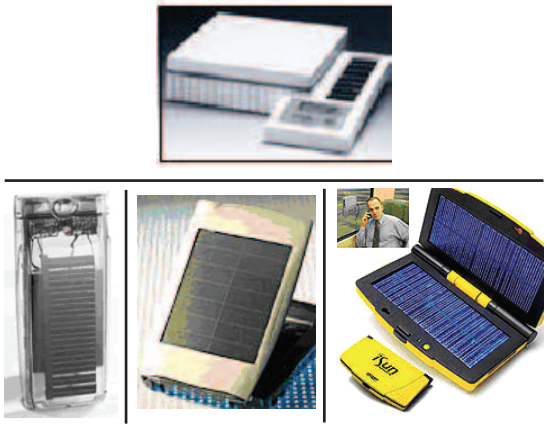


FIGURE 6-3 ___ EXAMPLES OF PV-POWERED PRODUCTS; WEIGHT SCALE, MOBILE TELEPHONE, PDA AND A SOLAR CHARGER FOR MOBILE TELEPHONES.

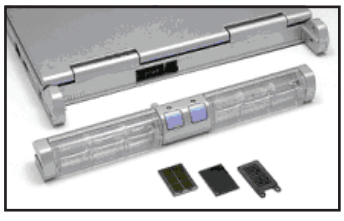
FIGURE 6-4 ___ EXAMPLES OF HUMAN-POWERED PRODUCTS: TWO TORCHES AND A MOBILE CHARGER.

FUEL CELL POWERED PRODUCTS

Since the miniaturisation and commercialisation of the Fuel Cell technology is more recent, the number of product examples available in the market is limited. Figure 6-5 depicts a selection of fuel cell examples that are still in the experimental or prototype stage. In the first example, a PDA is fuelled using FC technology however the FC source is large in comparison to the product and not well integrated in the design. In the second example from formula zero (the racing cart), the FC has been integrated in the design, however it does not yet compare to the characteristics of competing technologies like combustion engines. In the last example, the integrated FC power operated laptop, the FC technology creates added value as it enables users to work at least twice the amount of hours independent from the electricity grid.

Additional information on design processes for integrating renewable energy systems into products can be found in Module I of the web.

Many mobility and transport products featuring fuel cell technology are currently being developed. However, innovative mobility initiatives need to be accompanied with supporting infrastructural systems, supply, user practices and regulations (see Section 6.5).



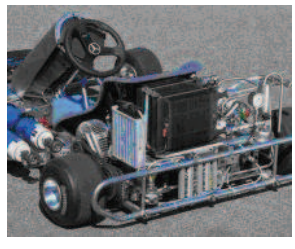


FIGURE 6-5 ___ EXAMPLES OF FC-POWERED PRODUCTS; PDA, RACING CART AND A FC-POWERED LAPTOP.

6.4 ICT TECHNOLOGY IN NEW PRODUCT DEVELOPMENT: ONE LAPTOP PER CHILD

The One Laptop per Child project has created a learning tool expressly for the world's poorest and underprivileged children inhabiting remote areas. The laptop was designed collaboratively by experts from both academia and industry. The Media dubbed the project 'One Laptop per Child' but industry members knew it as 'the $100 laptop.' The expected manufacturing cost is below $150 and expected to fall below $100 by the end of 2008.

"It should be compact and sealed, like a suitcase. And it should really look and feel different. It shouldn't look like something for business that's been colored for kids." (That's more than an aesthetic concern: An unmistakable, childlike design will be the laptop's only real defense against theft and resale.) The result is a unique harmony of form and function; a flexible, ultra low-cost, power-efficient, responsive, and durable machine with which nations of the emerging world can leapfrog decades of development—immediately transforming the content and quality of their children's learning.

The product development team explored several options. One of the first decisions was to place the bulk of the electronic wiring behind the display, like an iMac, instead of beneath the keyboard. This simplified the wiring as the motherboard and display were no longer connected through a fragile hinge and also cut costs. The new laptop designed by the One Laptop per Child project contains a number of innovations designed to reduce cost and make it practical for children in developing countries. A few of these design innovations are listed below. Furthermore, Figures 6-6 and 6-7 depict the final design and evolutionary stages of the design process, respectively.

- Renewable Energy: The low energy display and drive has made it possible to build a computer that consumes only 2 watts of power, compared with the 25 to 45 watts consumed by conventional laptops. Each machine is accompanied with a simple mechanism to recharge itself when a standard power outlet is not available. The project team experimented with a crank, but eventually discarded the idea because it seemed too fragile.

- Low energy display: The small high resolution screen has both a low-power monochrome mode – readable in sunlight, unlike conventional displays – and backlit color using light emitting diodes (LEDs).

- Low energy drive: The ultra-low-power operation is possible because of the lack of a hard drive (the laptop uses solid-state memory, which has no moving parts and has fallen sharply in cost). In addition the microprocessor shuts down whenever the computer is not processing information.

- Wifi and USB ports: Two design challenges included unprotected USB ports and a pair of radio antennas needing to be exterior to the machine for reception. A dual solution was designed which turned the antennas into a pair of playful 'ears' that swivel up for reception or down to cover the laptop's exposed USB ports.

"Everything on the laptop serves at least two purposes"

FIGURE 6-6 ___ THE FINAL CONCEPT

FIGURE 6-7 ___ THE EVOLUTION OF THE CONCEPTS

6.5 SYSTEM LEVEL INNOVATION CONNECTED TO NEW PRODUCTS: THE EXAMPLE OF FUEL CELL SYSTEMS

Fuel cell and hydrogen technologies utilising renewable energy sources offer great potential in the realm of innovation product systems and can provide the necessary energy efficiency in urban transportation systems to mitigate climate change through reduced emissions. Several hydrogen powered (fuel or fuel-cell) vehicle demonstration projects are underway. However, new products featuring fuel cell technology instead of conventional energy sources are only part of a much larger system that needs to be changed.

Typically, system innovation must be accompanied with radical changes in technologies, regulations, user practices, markets, culture, infrastructure, and supply networks to further support widespread uptake of the technology. System innovations require large investments and will always replace defunct parts of the existing system which often leads to opposition from actors connected to the old system.

An important aspect of system innovation management is learning-by-doing, keeping several options open for exploration, maintaining long-term vision and short-term actions, involving all relevant stakeholders and evaluating continuously (see also the bricolage approach, Chapter 5).

System innovation is a relatively new field with limited practical experience. A methodology was developed to address the need for concrete insights in initiating system innovation and was pilot tested in fuel cell transport system in Rotterdam.

This methodology emphasises outlining a combined set of concrete short-term projects and conditions, within a long-term perspective. The approach is characterised as 'bottom-up' as it involves relevant stakeholders very early in the process, in order to build upon current projects and views and support short-term projects with long-term objectives. The approach includes both current and future stakeholders in the process.

The following steps are performed in chronological order:

> *Draw a system definition:* a system innovation or a transition consists of a combination of different subsystems fulfilling various functions. These functions can involve changes in existing functions or implementing new functions. The system definition includes both technical and sociocultural elements, as change is required in all these dimensions in order to bring about a transition.

> *Identify stakeholders:* the different functions of the system definition can be associated with clusters of stakeholders that are necessary to fulfill these functions. It is essential that present stakeholders as well as potential stakeholders are involved. Small entrepreneurs are often more motivated than incumbent firms to manufacture the new technologies required for system innovation, for example, fuel cells.

> *Perform stakeholder interviews and workshops:* a transition or system innovation can only take place due to a collective action of the different stakeholders. Therefore, it is crucial to obtain stakeholder commitment. Furthermore it is assumed that system innovation can only be successful if it is based on a common vision and ideas. Insight into stakeholders reaction to system innovation (their views and perceived barriers and opportunities) can be obtained through in-depth interviews and workshops. The interviews should be aimed to obtain in-depth insight into the views of a wide variety of stakeholders. The workshops should facilitate interaction between different groups of stakeholders. In this way consensus regarding certain issues can be achieved. Also, the workshop contributes to the origination of stakeholder networks.

> *Generate a roadmap*: the results from interviews and workshops should be used to create a roadmap. The roadmap should include the most promising short- and medium-term projects for D4S and relate these to long-term objectives. The purpose of the roadmap is to identify and visualise potential innovation steps between the present situation and a possible sustainable future situation. The timeline and content of the roadmap should relate to existing roadmaps, in order to incorporate the national and international context.

A roadmap can be used to develop the transition steps necessary to implement system innovation. An important aspect of this method is that stakeholders are identified and consulted before the roadmap is developed. The roadmap should not be regarded as a fixed path; the transition steps need to be continuously evaluated based on the interim objectives developed by stakeholders. Because the transition projects and related conditions are based on the views of stakeholders, the methodology actively engages stakeholder commitment. The following case study outlines a D4S system innovation in the fuel cell transport field.

FUEL CELL TRANSPORT IN ROTTERDAM

The following case study provides the design approach for the fuel cell based transport system in Rotterdam. The design called for changes in infrastructure to accommodate the necessary storage, transport and distribution of hydrogen; filling stations; the production and supply of fuel cell vehicles and ships and the operation of these vehicles. Furthermore, the design requires

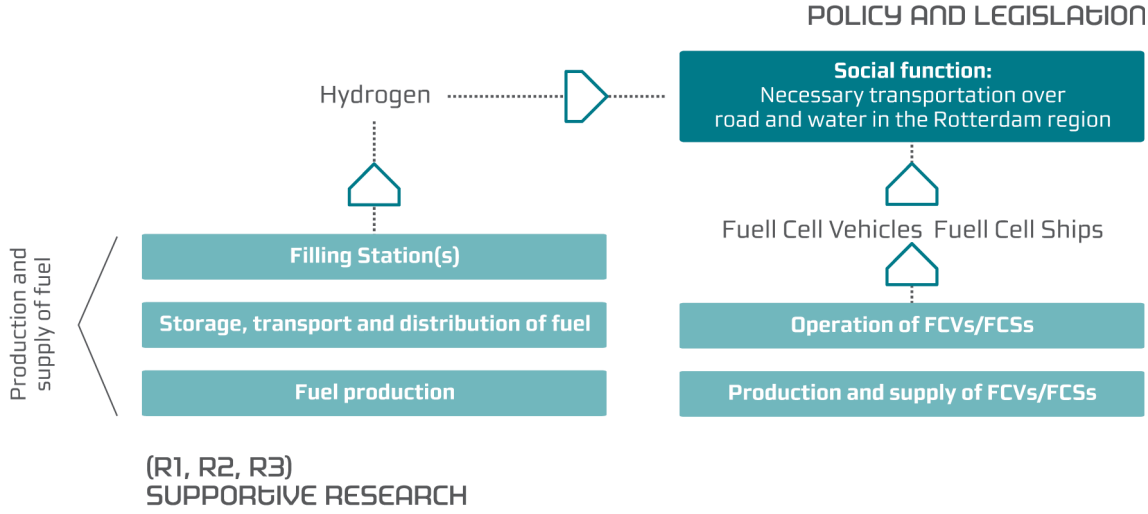


FIGURE 6-8 ___ SYSTEM DESIGN FOR FUTURE FUEL CELL TRANSPORT SYSTEM IN ROTTERDAM (VAN DEN BOSCH ET AL, 2005)

changes in policy and legislation to transition into the fuel cell transportation option. Figure 6-8 outlines the overall design.

All relevant stakeholders were interviewed to gather information and insight on how they perceive implementing short-term projects on fuel cell transport. Both vehicle and water taxi producers and suppliers demonstrated proactive attitudes towards fuel cells. The policy and legislation sector was also positive. The vehicle and water taxi fleet owners were willing to participate but were less enthusiastic. To ensure the commitment of all three groups, transition steps should meet commercial, learning, and sustainability objectives.

A workshop was held during which the various conditions and preconditions of stakeholders were further defined, and ideas for a number of concrete fuel cell projects were developed. The most promising ideas were used as input in the roadmap. The roadmap (see Figure 6-9) was used to put the short-term projects into a long-term perspective.

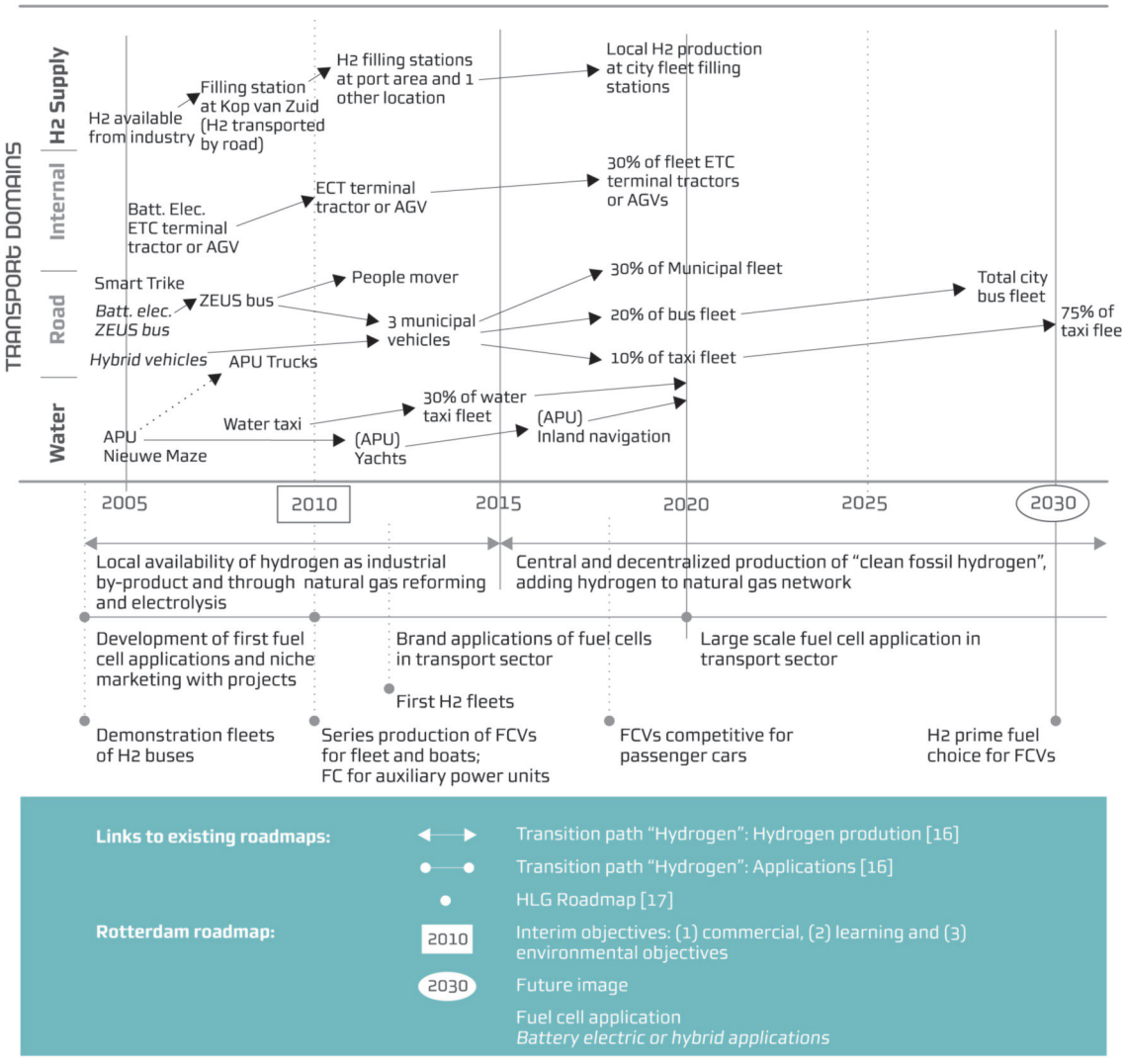


FIGURE 6-9 ___ ROADMAP FOR FUEL CELL TRANSPORT SYSTEM IN ROTTERDAM

The three transport domains: water, road, and internal transport, along with the required infrastructure (vertical axis) were distinguished, and the developments are followed in time (horizontal axis) connected to targets and phases of Dutch and European roadmaps. The promising fuel cell projects were depicted, and connected into various subpaths within the overall transition path. The roadmap is presented in Figure 6-9.

The primary focus of the roadmap is that the transition path utilises hydrogen available from the Rotterdam industry in the fuel cell projects. 'Internal transport' is an ideal area to carry out pilot projects, because it is less affected by rules and regulations. Furthermore, demonstration projects with battery electric or hybrid transport applications can be used as stepping stones to introduce fuel cell transport applications. The roadmap also supports an integrative approach with regard to the different transport domains, water, road, and internal transport; interaction between projects in all domains is necessary to increase knowledge and stimulate learning.

Rotterdam is not the only city active in hydrogen and fuel cell systems development. 'Hydrogen highway' systems, including both vehicles and infrastructure, are being developed in Canada, the US, and also in Germany. However, because these projects are part of much larger system innovations, risks and uncertainties are large, and competing systems based on electricity or biofuels are also being developed. No statements regarding the outcomes of these projects are available. In all cases, a long-term vision, commitment, and the pro-active role of industry, government, and knowledge institutes are essential.

In this chapter the approach for new sustainable product development was introduced. A general description of the approach is followed by the opportunities that new product technologies provide for the development of new, more sustainable products. Key renewable energy technologies are detailed with their potential advantages, as well as some examples of ICT technologies. The link with new products as part of system innovation is made, and the example of fuel cell systems is given. In the next chapter, another key approach for radical sustainable product innovation is presented: Product-Service Systems (PSS).

007 PRODUCT-SERVICE SYSTEMS

URSULA TISCHNER, CHRIS RYAN AND CARLO VEZZOLI

In addition to new product development (Chapter 6), development of Product-Service Systems (PSS) is another approach to radical sustainable innovation for D4S. The concept of PSS stems from the fact that services and products are becoming more and more intertwined. If Product-Service Systems are properly designed, they can be more sustainable then purely product-based solutions and thus can achieve higher factor improvements. In this Chapter the concept of PSS is introduced, three types of PSS are defined, and a step-by-step approach for a PSS pilot project is given. More information on the theoretical background of PSS is provided in Module C on the web. As in previous chapters, this approach has a strong connection to the basic four-step methodology for product innovation.

7.1 INTRODUCTION – THE CONCEPT OF PRODUCT-SERVICE SYSTEMS

In today's economy, companies normally deliver value by offering products or services to other companies, public entities, or individual customers. Most companies operate primarily within a product-based or a service-based system.

Product producers typically design and manufacture a product to sell directly to consumers, or manufacture a component to sell to another producer, or to be incorporated into a product which is then sold to consumers. In some market sectors, particularly for 'intelligent' products such as computers and mobile phones, producers may also add services (such as software, data, or communications) to enhance the value and utility of the product.

Service providers operate in a different part of the market. A major part of the economy in most industrialised countries is now based on the production and sale of services (about 75% of the GDP in the US and about 50% of the GDP in Europe). Some services are dependent on products for their utility and value. Many communications companies, for example, require mobile phones to deliver services.

Increasing integration of products and services is becoming more and more apparent in industrialised economies. However, as most companies have developed knowledge and optimised organisation in one specific area, such as product development, they may lack of knowledge and organisation in service development. Given this example, they may not be well prepared for a shift in the marketplace.

The PSS approach to D4S was formulated to help companies transition to a more integrated product and service market. It is a promising approach for companies wanting to grow in a market that is rapidly changing and shaped by environmental and social concerns and regulations. The concept of PSS proposes that companies transition from selling only 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.

The concept of PSS, as a business and design strategy, is the result of the growing interdependence of products and services in the current economy. It is clear that in the modern economy, the value derived from production and consumption depends on a series of services, which support the production and operational utility of products. The utility and value of a product derives from the 'service' which it provides for the con-

sumer. This is an important way to think about the product design process. For many products, delivering utility and value require additional services such as maintenance, information and support, spare-parts, consumables and software, and so on. These services are necessary to ensure a product 'works' for the consumer.

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 generally considered to be sold at a discounted price because of the future income to the manufacturer that will come from the long-term sales of ink cartridges. As a strategy for innovation, PSS can be thought of as widening the scope for design and development to include coordination and re-configuration of a set of products and services to meet customer needs in a more economic, environmentally efficient and socially sensitive way.

Based on research, analysis, and exploratory case studies, it is possible to design an appropriate *system* of products and services (PSS) which could:

> Be commercially viable in the current or future market place and deliver more value to companies and customers (economic dimension).

> Decouple the creation of value from consumption of materials and energy and thus significantly reduce the life-cycle environmental load of current product systems leading to factor 4 to factor 10 improvements in eco-efficiency (environmental dimension).

> Fulfill client's demands in a more appropriate way and thus create better quality of life for all stakeholders (social dimension).

PSS has significant potential to lead to radical innovation and D4S solutions for companies and customers/consumers, because the entire production and consumption system is rethought, as opposed to the simple redesign and improvement of existing products and systems in other approaches. PSS offers the opportunity to decouple value creation from environmental consumption by selling services instead of material products.

However, these benefits do not occur automatically; they have to be carefully designed into every new PSS. This Chapter and the corresponding section on the web (Module C) describes the methodologies and tools that can be used to enable companies to do so.

WHY SHOULD BUSINESS AND DESIGNERS CONSIDER PSS FOR D4S?

PSS is an innovative approach to sustainable business and may allow a company to:

> find new markets and profit centres;

> survive in rapidly changing markets;

> increase efficiency and reduce resource consumption;

> comply with environmental and labour regulations, or meet environmental and labour standards; and

> compete in the market and generate value and social quality, while decreasing total negative environmental and social impact (directly or indirectly).

In other words, PSS suggests a way to identify potential win-win solutions – for producers, providers, customers, stakeholders and the environment.

PSS proposes that a producer (often in partnership with other businesses) expands the role in the market to better coordinate and control the mix of products and services to meet customer demand with lower total adverse environmental and social impacts.

PSS is a very customer-focused strategy which draws on customer and consumer demands and needs. It allows producers to optimise market value while reducing environmental and social impacts, which can yield *higher operating efficiencies* and *improved strategic positioning*.

Enhancing operating efficiency. A shift to PSS can result in a situation where a company operates at the same or increased profit levels while reducing material and energy consumption (decoupling) and promoting sound human resource policies. A company can make more money if it can meet the same customer demand by providing a less resource-intensive product-service mix. Companies can also boost production efficiency by maintaining positive employee relationships.

Improved strategic positioning. PSS may improve a company's strategic position in the market because of the added value perceived by clients. Improved strategic positioning could be obtained as a result of:

> ***New market development*** – opening up a new business niche (even in saturated markets)

> ***Increased flexibility*** – responding more rapidly to the changing market

Business Aim	Strategy (starting point for PSS development)
Develop new income streams; Postpone disposal costs (from product take back); Reduce costs of new product design and development.	Introduce new high value services to extend life of product, through maintenance, repair and upgrading.
Develop a market for a higher quality, more technically and environmentally efficient, but more expensive product.	Offer the product for lease or for shared use.
Free customers from inconvenient responsibilities for managing hazardous substances, return of end-of-life products, recycling etc.	Introduce appropriate services to manage materials and end-of-life; enter into partnerships with specialist organisations to handle these services where hazardous or valuable material concerned.
Reduce resource consumption of product in use increase efficiency of product as a competitive edge.	Provide support services that assist optimum use patterns by customers.
Increase customer satisfaction; Increase customer loyalty; Build enduring producer-customer relationship.	Customise products and services to specific user needs; Work with customers to design new products and services; Lease products, with service contracts focusing on results, utility, required by customers.
Develop new market niche; Improve brand image.	Start new business unit with new PSS offer to (a) preserve the operations of an existing business and (b) expand the diversity of its market activity.

TABLE 7-1 ___ MOTIVATIONS EXPRESSED BY COMPANIES THAT HAVE EXPLORED OR DEVELOPED NEW PSS

> ***Longer term, more direct, client relationships –*** most PSS lead to stronger company-customer relationships.

> ***Improved corporate identity*** – 'responsible and transparent' – companies clearly show their environmental and social benefits

Table 7-1 lists some motivations expressed by companies that have explored or developed new PSS.

To varying degrees all PSS approaches change the existing relationship between production and consumption. Therefore a company must be open to new opportunities and business relationships. This can mean changing the existing corporate culture and organisation to support a more systemic innovation and service-oriented business. In many cases it also means reaching out to find corporate partners and creating new alliances between companies with complementary market experiences and skills (e.g. manufacturers partnering with service companies).

A PSS approach requires companies and providers to develop:

> A managerial vision for system innovation: the ability to recognise new opportunities and to design new product service mixes that meet customer demands.

> An innovative corporate culture capable of promoting new forms of internal organisation, e.g. to coordinate the product-service co-development.

> An innovative corporate culture capable of promoting new forms of external partnerships and having the ability to interact on new levels with different stakeholders.

> A knowledge of the opportunities offered by Information and Communication Technology (ICT) (see Module J) for the realisation and application of PSS.

More information on the theoretical background of PSS is given in Module C.

7.2 PRODUCT-SERVICE SYSTEMS FOR D4S – SOME STARTING POINTS

PSS for D4S requires motivation for changes similar to those described above. It also requires a process to identify strategic opportunities, based on a review of current market demands and trends and the existing system through which customer satisfaction is fulfilled. The concept of PSS allows for many different combinations of products and services to optimise commercial,

PSS starting point.	Typical examples	Environmental change	Social change	End-of-life issues
1. *Adding services to a product.* In this PSS approach *the customer owns the product, and* the producer sells new services along with products. These new services can increase the service or information intensity of the product (see '5' below) and/or support the functional efficiency of product operation and use.	Maintenance and repairs; education (user advice and support); up-grades (both hardware and software) and product refurbishment; extending functional range of product (for example, mobile phones). Typically, service contracts provide the appropriate services over a specified period of time.	Improved environmental performance can include: optimising product efficiency (during production and use); extending product life, better utilisation of the energy and materials embodied in the product (improving the efficiency or value of product without having to replace it); reducing energy consumption in transport and storage.	Improved social performance can include: better employment/working conditions, higher equity and justice in relation to stakeholders, mobilise responsible/sustainable consumption, favour/integrate the weaker and marginalised, improve social cohesion, empower/enhance local resources.	When the period of the service contract is over, the PSS provider may offer, as an additional service, to take the product back and deal with refurbishment, remanufacturing etc.
2. *Providing 'the use of a product' for a customer.* In this PSS approach, the *producer maintains ownership of the product,* with the customer paying to use it. Typically these services involve leasing or renting contracts. Such PSS provide customers with access to high quality products when they need them, with the producer taking care of their maintenance, etc. The design focus for the PSS is providing highest value outcome for client, meeting their needs without product ownership.	Hiring, leasing or renting products such as computers, office furniture and furnishings, office equipment; cameras; car-sharing systems; shared full-service office arrangements; washing machines, and in the home (pay-by-use systems); 'Laundromats'.	Improved environmental performance can flow from: fewer number of products necessary to support user demands; higher quality, more efficient products (higher investment in products that would be too expensive for sale, but attractive for lease); increased intensity of product use (using up the full service capacity of a product in a shorter time) can allow for faster flow of innovation in product design.	Improved social performance similar to 1.	As the products remain in the ownership of the producers, the interest of the producer is to maximise their value at the end of their (first) life, through refurbishment, remanufacturing, and reducing any waste costs.
3. *Facilitating the shared use of products.* In this PSS model, products are either *owned by the producer, or collectively owned by multiple consumers* (for example, through local governments). Producers sell a package of products and maintenance services or systems to support shared use.	A serviced laundry in an apartment block with an effective 'booking' and monitoring system; power-tool sharing systems; car pooling; car sharing (in cities, towns or amongst residents of an apartment block).	Improved environmental performance similar to 2.	Improved social performance similar to 1.	PSS provider either owns the product or can include take back and remanufacturing in the service contract.
4. *The delivery of results to a customer or consumer.* This PSS focuses on the provision of an integrated solution to meet customer needs; 'results' means an agreed performance of a system for a customer. Typically (but not in all cases) *the producer will keep ownership of any product(s) involved,* with the customer paying just for agreed results. In most cases the producer will maintain control, maintenance etc., of the operation of any product(s) as part of their service contract. This differs from the previous PSS model (2) in that the customer or consumer is not concerned directly with the use of the product(s) involved, but only interested in the results.	A company sells 'thermal comfort' for a building (instead of heating and cooling equipment); a company sells 'pest control'; an office company sells 'copied documents' rather than photocopiers; a company provides healthy air for offices (through the provision and maintenance of a living indoor garden).	Improved environmental performance can flow from optimising the efficiency of the system of products and infrastructure providing the result (the functional outcome the customer requires), increasing product life, and maintaining performance efficiency.	Improved social performance similar to 1.	The PSS provider has some incentive to maximise the value of the product at end-of-life, to deal with refurbishment, remanufacturing and responsible disposal.
5. *Replacing material products with information services.* This PSS model aims to substitute digital information for a material product. Information intensive products can be replaced by a 'flow' of information. Material products can become virtual products. [please refer to Module J for additional information on ICT]	Web based information, booking or payment systems - a phone book on the web or CD-ROM; maps on computer screens or mobile phones; video conferencing; on-line financial transactions; digital music files; digital images.	Improved environmental performance can flow from reducing material and resource use, substituting information 'bits' for 'atoms'.	Improved social performance similar to 1.	The digital component doesn't need end-of-life treatment; but all associated products (such as computers, etc.) still need to be taken into account.

TABLE 7-2 ___ FIVE STARTING POINTS FOR THE DEVELOPMENT OF NEW PRODUCT-SERVICE SYSTEMS. (THESE APPROACHES ARE INTRODUCED AS WAYS OF THINKING ABOUT PSS. THEY ARE NOT MODELS AND THEY ARE NOT DISCRETE, THEY OVERLAP AND COMBINATIONS ARE POSSIBLE.)

PSS Type	Key characteristics	Examples
Product Oriented PSS (POPSS)	The consumer owns the product; a company provides additional services to assure the functionality, durability and performance/use of the product.	Service contract for maintenance, repair and take back added to high tech products.
Use Oriented PSS (UOPSS)	Service provider owns the product, selling only the function to customer through a service contract.	Car sharing; serviced office space.
Results Oriented PSS (ROPSS)	The customer buys results and is not concerned with how those results are delivered.	Selling pest free fields instead of pesticides; selling thermal comfort in buildings instead of heating and cooling equipment (contracting); selling high quality application of chemicals, instead of selling the chemicals (chemical management).

TABLE 7-3 ___ TYPICAL CLASSIFICATION OF PSS.

environmental, and social returns. To explore the potential of PSS for an existing business or product, or to begin to develop a new product-service, it is useful to look at various case-studies to understand what approaches others have taken and what models have emerged. A number of research projects have examined case studies that employ a PSS approach and several PSS models have been generated from that research. Other projects have worked with companies to explore and implement new PSS and develop models and methodologies in the process. Module C on the web contains various short case studies from these research projects and web references to related programmes in the resources section.

PSS approaches can be classified in various ways. Although there is continuing interest in defining a set of models to guide PSS development, this Chapter does not provide any one comprehensive template, it outlines starting points and a guiding process. The aim is to assist companies and new partnerships in innovation through 'thinking about PSS'. As a beginning, Table 7-2 describes five different approaches to 'thinking about PSS', focusing on the ways that existing customer needs can be met in new ways through PSS related changes.

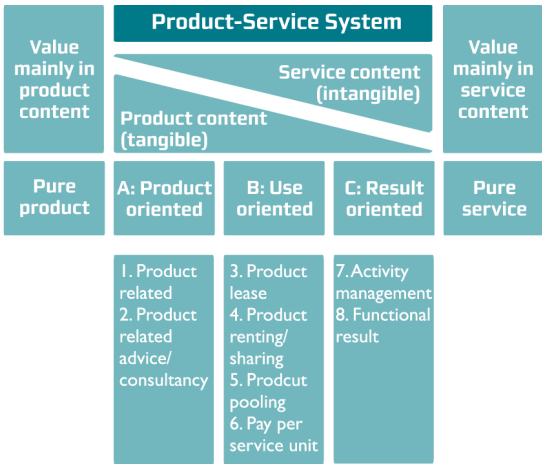


FIGURE 7-1 ___ ONE TYPICAL PSS CATEGORISATION WITH THREE MAIN CATEGORIES AND EIGHT SUB-CATEGORIES.

PSS initiatives are generally classified to assist stakeholders in understanding the objectives, needs, and expected outcomes of radical sustainable innovation projects in D4S. There are three broad categories used to classify PSS and eight sub-categories to further refine the PSS directives. Table 7-3 defines the key characteristics of the primary PSS categories and Figure 7-1 depicts the overall classification scheme.

This PSS classification allows for a logical grouping of virtually all types of product-service value propositions that one can think of, including 'immaterial' offerings such as (non-product related) advice and consultancy (which is a pure service). However, as with any 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.

> Case: An example of a successfully implemented PSS for D4S is the Call–A-Bike system in Germany, as it was introduced throughout the country by German Rail – see Case Study section on the web.

The PSS approach is taking off in industrialised countries, but can also be of great value for the developing world. PSS can help developing countries leapfrog to more sustainable patterns of production and consumption, since the existing structure of products and services are often not well developed. In developing economies where labour is abundant and income levels are relatively low, PSS can provide considerable benefits. For example, if community members cannot afford individually owned tools or appliances, products and services can be sold on limited ownership. Establishing PSS systems that effectively meet consumer needs can counter increasing consumption pressures for the private ownership of goods. A widespread example of a PSS in developing economies is the service of mobile phone calls in rural villages in several countries, where calls can be on a shared mobile phone, whereby the owner of the phone receives a small fee.

An example of a PSS clothing care system in Delhi, India is provided in Module C.

7.3 HOW TO RUN A PSS FOR D4S PILOT PROJECT

WHAT IS NEW IN THE PSS BUSINESS AND DESIGN APPROACH?

For efficient PSS development, both the product and service sides have to merge, and be integrated in market research and innovation activities including the formulation of design specifications, the timeframe for design implementation, and the actual delivery of the PSS on the market to increase efficiency and success. Today, it often happens that both sides (products and services) are not coordinated or well connected, leading only to sub-optimal results. For instance some service providers, e.g. mobile communication providers have difficulties in their business model because the product producers, e.g. mobile phone producers, do not respond to their demands, do not deliver the products in time, and do not adequately handle repairs, which reduces the customer's satisfaction and perception of the providers. Customers view providers as being responsible for a complete telecommunication service (including phones).

The following paragraphs describe how both products and services can be developed together, more strategically and efficiently in a manner that takes into account environmental, social, and economic aspects. This approach leads to more sustainable business and consumption strategies.

It is often necessary to engage additional partners in the design process; for example, in a formerly product-oriented company, the company's service side must be developed to balance competencies. It is recommended that companies involve other organisations and consumers in this process in order to build capacity.

The ultimate goal of this approach is to fulfill the customer's and consumer's demands in a sustainable way (deliver satisfaction) – gain more profit, and create more value at the same time. In PSS, customer demands are the focus of business activities and the company searches for the most efficient and effective combination of products and services to fulfill the customer's needs. This approach offers a great opportunity to move the entire production and consumption system towards sustainability.

HOW TO START?

Before trying to restructure the entire organisation or create a company on a new business idea, the company should develop and implement a pilot project. The aim of such a project is to analyse the PSS business opportunities, to find out how the new PSS design and development process can work, to experiment with new PSS tools, and finally to develop new PSS for D4S solutions and test them, e.g. in a niche market, before the company or consortium of companies decide to enter a bigger market.

One recommended approach for such a pilot project is described below. For more detailed information on the pilot project approach, please see Module C on the web. The pilot project will assist companies in the following five areas:

1> Exploring opportunities, identifying and analysing the existing reference system;

2> Generating PSS ideas and selecting the most promising concepts;

3> Detailing selected PSS concepts;

4> Evaluating and testing detailed PSS concept(s); and

5> Planning implementation.

Following the pilot project, the company will evaluate the results and decide whether to proceed with the full scale implementation of the new solution. The pilot project process is very company and solution specific, thus only the generic aspects will be mentioned here.

The five phases correlate with the four basic steps for product innovation (see Section 2.6), whereby the last two PSS phases (evaluation and planning of implementation) can be seen as detailing of the fourth product innovation step 'realisation.'

THE PSS FOR D4S PILOT PROJECT

The challenge of the pilot project is to develop and explore business strategies to fulfill customer and consumer demands in a sustainable way – and to create more value and profit at the same time. This is done by exploring and assessing the PSS opportunities for a company in a specific market, that have the potential for sustainability improvement.

The following pragmatic approach is suggested: A company should start with qualitative tools and analyses, and transition to (semi-)quantitative tools whenever possible and as time allows. It is important that the data collection process is realistic provided the timeframe and resources available to the team.

The following table describes the steps of the pilot project and suggested tools. The following description of the pilot project only describes simple and time efficient ('quick and dirty') tools. See Module C on the web for more details.

The stepwise approach in the PSS pilot project can be carried out by organising workshops for each or some of the different steps involving a multidisciplinary team. The following internal experts are recommended to be involved:

> Strategic management;
> Marketing and public relations;
> Research and development (designers, engineers and product managers);
> Purchase and procurement;
> Retail; and
> Customer services.

Furthermore, it might be sensible to invite external stakeholders including:

> PSS and D4S experts;
> Trend and scenario analysts;
> Environmental analysts;
> Social and labour policy analysts;
> Customers and other stakeholders (NGOs, Media); and
> Potential or actual co-operating partners (suppliers).

More information on PSS can be found in Module C, where this stepwise approach is further detailed, and additional tools are presented that are helpful and are recommended for use for a more detailed approach. This is followed by a short introduction to integrating PSS thinking and innovation into company practice. Additional case studies and best practice examples are presented that show how the PSS approach works in practice.

Steps in the pilot project	Suggested tools
1. Exploring opportunities: identification and analysis of the existing reference system	- *Drawing a system map/ Blueprinting* - *Sustainability SWOT* - *Checklist for analysing existing reference system*
2. PSS idea generation and selection of the most promising concepts	- *Sustainability Guidelines Level 1* - *Format of PSS concept description* - *PSS Sustainability Screening Tool* - *Portfolio Diagram Sustainability and Feasibility*
3. Detailing selected PSS concepts or PSS design	- *Sustainability Guidelines level 2* - *Extended system map of the new system/ blueprint* - *Extended description of the new system* - *First Advertisement for the new system*
4. Evaluation of the detailed concepts and testing if possible	- *Three Sustainability Radars for the three sustainability dimensions with six criteria each*
5. Planning implementation	- *List of specifications for PSS implementation* - *Business plan for new PSS*

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WEBSITES
http://www.laptop.org/index.en_US.html
PSS the European MEPPS project: www.mepss.nl
PSS the European SusProNet project: see www.sus-pronet.org

Evaluation Questionnaire

DESIGN FOR SUSTAINABILITY

A Step-by-step Approach

As part of its continuing review of the impact of its publications and projects it supports, the United Nations Environment Programme's Division of Technology, Industry, and Economics would appreciate your co-operation in completing the following questionnaire.

1> QUALITY

Please rate the following quality aspects of the publication by ticking the appropriate box:

	VERY GOOD	ADEQUATE	POOR
Objectivity	O	O	O
Rigour of Analysis	O	O	O
Up-to-Date	O	O	O
Readability	O	O	O
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Presentation	O	O	O

2> USEFULNESS

In general, how much of the publication is:

	MOST	ABOUT HALF	LITTLE
Of technical/substantive value to you?	O	O	O
Relevant to you?	O	O	O
New to you?	O	O	O
Will be used by you?	O	O	O

3> EFFECTIVENESS IN ACHIEVING THE OBJECTIVE

The objective of this publication is to give readers information on what is meant by the concept of D4S, current barriers to improved implementation, an action list on how to overcome these barriers and appendices of existing information sources. In your opinion, to what extent will the publication contribute to the achievement of this objective?

Please tick one box O FULLY O ADEQUATELY O INADEQUATELY

Please state reasons for your rating

4> USES

a. Please state how publication will affect or contribute to your work, illustrating your answers with examples.

b. Please indicate, in order of importance (first, second, or third), the usefulness of the publication to you

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Your name (optional):

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UNEP would like to thank you for completing this questionnaire. Please photocopy and airmail (or scan) to:

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About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

> sustainable consumption and production,
> the efficient use of renewable energy,
> adequate management of chemicals,
> the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

> The International Environmental Technology Centre - IETC (Osaka, Shiga), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.

> Sustainable Consumption and Production (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.

> Chemicals (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.

> Energy (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.

> OzonAction (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.

> Economics and Trade (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

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Design for Sustainability (D4S), improving products while taking environmental and social concerns as key strategic elements into consideration, is one of the most useful innovation approaches available to enterprises today.

Design for Sustainability A Step-by-Step Approach provides an overview of D4S and explains how to apply the D4S methodology. The publication, a compilation of efforts from global leaders in the field, explores not only incremental redesign, but also radical innovation, new product design, and the concept of Product-Service Systems. Clear reference information and supporting case studies are also provided.

The publication targets designers and other professionals working in the area of industrial product development. It is useful to those new to ecodesign as well as those interested in breakthrough innovation for sustainability. This is a sister publication to "Design for Sustainability: A Practical Approach for Developing Economies" (2006) which focused on the specific needs of small- and medium-sized companies in developing economies.

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