PART II

HOW TO DO D4S IN PRACTICE
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 manager, 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.

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 IMPACT 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.

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

TABLE 3-1(a) - ENVIRONMENTAL IMPACT AREAS

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

TABLE 3-1(b) - SOCIAL IMPACT AREAS

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]
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’,
<table>
<thead>
<tr>
<th>Product characteristics</th>
<th>Strategic focus</th>
<th>Questions about your product (dossier information)</th>
<th>D4S / improvement approaches</th>
<th>Notes on Environmental effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Selection of low impact materials</td>
<td>Can you identify any sensitive materials?</td>
<td>(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.</td>
<td>Biodiversity and social concerns reduced.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are any materials high in embodied energy (or embodied water if that is a scarce resource in your market)?</td>
<td>(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(iv) next (Product Life-time and end-of-life recovery) – embodied energy can be (partially) recovered through re-use and recycling.</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is anything in your product toxic to humans and/or ecosystems?</td>
<td>(iii) Eliminate toxic materials (e.g., lead or mercury) and any surface processing or treatments that introduce toxins in manufacturing, or which contaminate recovered/recycled materials (Link to A1(iv) or next below).</td>
<td>This is a critical issue for end-of-life products. The elimination of the toxic material will always be a more robust strategy than recovery and reuse/storage (where accidents can and do happen).</td>
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<tr>
<td></td>
<td>Are the materials in your product able to be recycled?</td>
<td>(iv) Try to use recycled material.</td>
<td>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.).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are there any recycled materials incorporated in the product?</td>
<td>(v) Use recyclable materials. Where possible Link to D2 Product Life-time and end-of-life recovery (v).</td>
<td>Use of recycled materials builds the market for re-use of materials at end of (first) life.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Could anything in our product be made from biodegradable materials?</td>
<td>(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.</td>
<td>Use of biodegradable materials avoids end-of-life waste accumulation.</td>
<td></td>
</tr>
<tr>
<td>2. Materials use</td>
<td>What is its total weight? Has the weight been optimised?</td>
<td>(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.</td>
<td>A reduction in total product weight reduces overall resource flows in the economy (de- materialization), lower extraction and processing impacts (less material consumed), lower transport impacts (a decrease in fuel consumption), link to B2 Distribution and Transport.</td>
<td></td>
</tr>
<tr>
<td>Component/Process</td>
<td>Step</td>
<td>Description</td>
<td>Benefits</td>
<td></td>
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<td>--------------------------------------------------------------------------------</td>
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<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>A. THE USE OF MATERIALS IN THE PRODUCT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How many different materials are used?</td>
<td>(i)</td>
<td>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.</td>
<td>Reduced materials can alleviate end-of-life concerns by easing recycling, materials reuse, and disposal.</td>
<td></td>
</tr>
<tr>
<td>How are components and different materials joined? Could other joining systems be used?</td>
<td>(ii)</td>
<td>Avoid bonding materials together; use mechanical fasteners or geometric patterns that allow components to be ‘snapped’ together. 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.</td>
<td>Improves ease of recycling (by avoiding composite materials) and end-of-life materials capture.</td>
<td></td>
</tr>
<tr>
<td>Packaging</td>
<td>(iii)</td>
<td>Link to D: Product life-time and end-of-life recovery.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What drives the packaging of the product? Safety, standards, image?</td>
<td>(iv)</td>
<td>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 recognizing these market limits, aim to reduce packaging materials.</td>
<td>Lower resource consumption (energy, materials, water).</td>
<td></td>
</tr>
<tr>
<td>1. Production and Manufacturing</td>
<td>(i)</td>
<td>Reduce inputs</td>
<td>Lower resource consumption (energy, materials, water).</td>
<td></td>
</tr>
<tr>
<td>What are the key resource inputs?</td>
<td>(ii)</td>
<td>[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).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are recovered resources, lower carbon energy sources or renewable energy already used? Manufacturing the product? Are there opportunities for this?</td>
<td>(iii)</td>
<td>Consider using renewable energy (or 'green power') or switch to lower carbon energy sources (e.g. from coal or oil to gas or biomass). Consider using recycled or recovered resources (e.g. water from one part of process as input to another).</td>
<td>Lower greenhouse gas emissions.</td>
<td></td>
</tr>
<tr>
<td>What are the key outputs of pollution and waste? Can pollution and waste be reduced?</td>
<td>(iv)</td>
<td>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.</td>
<td>Reduce waste – increase materials efficiency.</td>
<td></td>
</tr>
<tr>
<td>2. Distribution and Transport in all phases of the product life-cycle: logistics, distance, mode, and efficiency.</td>
<td>(i)</td>
<td>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).</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>How are products transported (what is the form or mode of transportation)?</td>
<td>(ii)</td>
<td>Change transport mode to a more efficient or less polluting means (e.g. from truck to rail).</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>How efficient are the transportation systems?</td>
<td>(iii)</td>
<td>Improve transport load efficiencies (higher utilisation rate).</td>
<td>Reduce resource use in transport. Less pollution is generated per product.</td>
<td></td>
</tr>
<tr>
<td>Can the weight of the product and packaging be reduced?</td>
<td>(iv)</td>
<td>Reduce weight of materials in the product as it is transported (see A2 (i) Materials use above).</td>
<td>Reduced weight requires less energy in the transportation of products and therefore less pollution.</td>
<td></td>
</tr>
</tbody>
</table>
### 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 lifecycle. |
| Could your product use renewable energy? | (ii) Use renewable energy when possible (e.g. solar energy to charge batteries). Also, use wastewater when possible. |
| Can user behaviour affect the resource demands of your product in use? In what way? | For energy consuming products switching to renewable sources will reduce greenhouse gas. |

### 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. |
| CSR can become a way of 'shaping' the design/innovation strategy of the company and has positive implications for image. |

### 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. |
| Decreases material flows (from total product to the 'fashion shelf'). |
| 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 because fewer products are produced to fulfill function / user needs. |
| 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 a heirloom). |

### C. SOCIAL AND ETHICAL ISSUES IN PRODUCTION, DISTRIBUTION OF USE

| 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. |
### E. Innovation and New Product Strategies

<table>
<thead>
<tr>
<th>1. Meet User Needs</th>
<th>2. Develop a Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify new用户需求</td>
<td>Create a new产品</td>
</tr>
<tr>
<td>Analyze and prioritize new opportunities</td>
<td>Conduct market research</td>
</tr>
<tr>
<td>Design new product</td>
<td>Test new product</td>
</tr>
<tr>
<td>Ensure technological integration</td>
<td>Refine new product</td>
</tr>
</tbody>
</table>

### D. Product Life-Time and End-of-Life Recovery

<table>
<thead>
<tr>
<th>1. End-of-life Life</th>
<th>2. Product Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyze the product life</td>
<td>Design for recoverability</td>
</tr>
<tr>
<td>Ensure the product is readily recyclable or reusable</td>
<td>Reduce the environmental impact of the product</td>
</tr>
<tr>
<td>Develop a recovery and disposal system</td>
<td>Ensure the product is adequately marked</td>
</tr>
</tbody>
</table>

### Product Life Cycle

- **Design for Remanufacturing**: Ensure that products can be easily disassembled and reassembled for remanufacturing.
- **Design for Recycling**: Use materials that are easily recyclable and ensure that the product is marked accordingly.
- **Design for Disposal**: Ensure that the product can be disposed of safely and that any hazardous materials are properly contained.

### Key Points

- **Minimize Waste**: Reduce the use of hazardous materials and ensure that any waste produced is properly managed.
- **Maximize Resource Efficiency**: Design products to require minimal resources and energy to produce.
- **Enhance Customer Satisfaction**: Ensure that products are easy to use and maintain, and that they meet customer needs effectively.

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*This image is a excerpt from a document that discusses the strategies for innovation and new product development, as well as the considerations for product life-time and end-of-life recovery.*
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 expe-
rience has shown that, for many products (particularly if
it is the first time that environmental or social improve-
ment 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 quali-
tative 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 dia-
gram (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 environ-
mental 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 cre-
ated 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 alter-
native approach to product assessment. (Even for
companies possessing the resources necessary
for conducting full LCA studies, the expert-work-
shop approach can be an effective way to assess
the potential positive outcomes of a D4S pilot
project.) The workshop usually requires a mix-
ture of people who are knowledgeable about the
different production and use aspects. This
includes insight from a technical, manufacturing
and performance perspective (those who sup-
plied the product data) and additionally the peo-
ple who are aware of the environmental and
social impacts. Unlike LCA software systems,
the expert workshop will not always produce quanti-
fied 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 stud-
ies 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]
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.
### Table 3.3: Product Type, Impact & Response

<table>
<thead>
<tr>
<th>Product type / characteristics</th>
<th>Typical impact profile</th>
<th>Knowledge focus (data you will need to gather for your product)</th>
<th>Most relevant D4S responses (the references link to Table 3.4 above)</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>(A) YES</td>
<td>- 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).</td>
<td>B3 (i); (ii); (iii) (energy/water focus) E1, E2 and E3 (Lower priority: A2(i) and D2.)</td>
</tr>
<tr>
<td></td>
<td>(B) NO (Passive product)</td>
<td>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 impacts 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).</td>
<td>A1 A2 A3 B1 B2 C1 D1 (High priority) D2</td>
</tr>
<tr>
<td>2. A mobile product? Is your product mobile or transported when in use? (e.g. a car or a container)</td>
<td>(A) YES</td>
<td>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.</td>
<td>A2 (i), B2 (ii); (iii); and (iv) B3 (i); (ii); (iii) Consider inputs to the mobility/transport process C1</td>
</tr>
<tr>
<td></td>
<td>(B) NO (Stationary product)</td>
<td>No conclusions. Examine other characteristics.</td>
<td></td>
</tr>
<tr>
<td>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).]</td>
<td>(A) YES</td>
<td>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.</td>
<td>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)</td>
</tr>
<tr>
<td></td>
<td>(B) NO (Passive product)</td>
<td>Consider 1B Passive Products (this table above).</td>
<td></td>
</tr>
<tr>
<td>4. A short-life product? Is your product consumable, a non-durable, a use-and-dispose?</td>
<td>(A) YES</td>
<td>Impact profile will emphasize 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.</td>
<td>A1 A2 A3 B1 B2 C1 D1 (Note: not appropriate if product is also a 1A [Active Product] or 3A [Consumable Product] type) D2</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th></th>
<th>1. Significant environmental (or social) gains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technically or economically difficult or uncertain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2. Significant environmental (or social) gains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technically or economically feasible</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>3. Limited environmental (or social) gains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technically or economically difficult or uncertain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>4. Limited environmental (or social) gains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technically or economically feasible</td>
</tr>
</tbody>
</table>
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.
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.

4.1 A STRUCTURED, STEPPED-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
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 will they 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 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.

**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).
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 be 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.

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
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 such as 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?
> 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 gases 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 aluminium 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 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
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 at least:

> 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.
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.
**Box 4-2 A: 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 than 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 B: 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 fulfill 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: Examples of application of D4S strategies for furniture, mobility, electronics and packaging products.**
1. **Electronics**

   **Low impact materials**
   Compared with its predecessor, the J22 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.

   **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.

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

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

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

   **Extension of the initial lifetime**
   Use of LED’s in traffic lights. LED’s have longer lifetime than the conventional lights sources in traffic lights. The new traffic lights need therefore also less maintenance.

   **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.

   **Other ways...to fulfill 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.

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2. **Packaging**

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

   **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.

   **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.

   **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.

   **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.

   **Other ways...to fulfill the function**
   Fleece clothing made from recycled PET.
> 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’.

**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 2004)_
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)

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**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.


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.
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.

There 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 order.

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) poses 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).
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

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

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 color 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 Freplay 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 Freplay 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.](image)

![Figure 6-4: Examples of human-powered products: two torches and a mobile charger.](image)
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 1 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).

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 under-privileged 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”

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 sub-systems 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
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.

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**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).
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
Develop new income streams;
Postpone disposal costs (from product take back);
Reduce costs of new product design and development.

Strategy (starting point for PSS development)
Introduce new high value services to extend life of product, through maintenance, repair and upgrading.

<table>
<thead>
<tr>
<th>Develop a market for a higher quality, more technically and environmentally efficient, but more expensive product.</th>
<th>Offer the product for lease or for shared use.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free customers from inconvenient responsibilities for managing hazardous substances, return of end-of-life products, recycling etc.</td>
<td>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.</td>
</tr>
<tr>
<td>Reduce resource consumption of product in use increase efficiency of product as a competitive edge.</td>
<td>Provide support services that assist optimum use patterns by customers.</td>
</tr>
<tr>
<td>Increase customer satisfaction; Increase customer loyalty; Build enduring producer-customer relationship.</td>
<td>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.</td>
</tr>
<tr>
<td>Develop new market niche; Improve brand image.</td>
<td>Start new business units with new PSS offer to (a) preserve the operations of an existing business and (b) expand the diversity of its market activity.</td>
</tr>
</tbody>
</table>

**TABLE 7-1: MOBILISATIONS 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,
<table>
<thead>
<tr>
<th>PSS starting point.</th>
<th>Typical examples</th>
<th>Environmental change</th>
<th>Social change</th>
<th>End-of-life issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>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.</td>
<td>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.</td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td>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 a product. 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.</td>
<td>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); 'Laundrytax',</td>
<td>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.</td>
<td>Improved social performance similar to 1.</td>
<td>As the products remain in the ownership of the provider, 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.</td>
</tr>
<tr>
<td>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.</td>
<td>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).</td>
<td>Improved environmental performance similar to 2.</td>
<td>Improved social performance similar to 1.</td>
<td>PSS provider either owns the product or can include take back and remanufacturing in the service contract.</td>
</tr>
<tr>
<td>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 products 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 products(s) involved, but only interested in the results.</td>
<td>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).</td>
<td>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.</td>
<td>Improved social performance similar to 1.</td>
<td>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.</td>
</tr>
<tr>
<td>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)</td>
<td>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.</td>
<td>Improved environmental performance can flow from reducing material and resource use, substituting information 'bits' for 'atoms'.</td>
<td>Improved social performance similar to 1.</td>
<td>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.</td>
</tr>
</tbody>
</table>
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.

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.

### Table 7-3 Typical Classification of PSS

<table>
<thead>
<tr>
<th>PSS Type</th>
<th>Key Characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Oriented PSS (POPSS)</td>
<td>The consumer owns the product; a company provides additional services to assure the functionality, durability and performance of the product.</td>
<td>Service contract for maintenance, repair and take back added to high tech products.</td>
</tr>
<tr>
<td>Use Oriented PSS (UOPSS)</td>
<td>Service provider owns the product, selling only the function to customer through a service contract.</td>
<td>Car sharing; serviced office space.</td>
</tr>
<tr>
<td>Results Oriented PSS (ROPSS)</td>
<td>The customer buys results and is not concerned with how those results are delivered.</td>
<td>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).</td>
</tr>
</tbody>
</table>

### Figure 7-1 One Typical PSS Categorisation with Three Main Categories and Eight Sub-Categories.
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 time-frame 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.

<table>
<thead>
<tr>
<th>Steps in the pilot project</th>
<th>Suggested tools</th>
</tr>
</thead>
</table>
| 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 |

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.