THE DESIGN OF ECO-EFFICIENT SERVICES

Method, tools and review of the case study based 'Designing Eco-efficient Services' project

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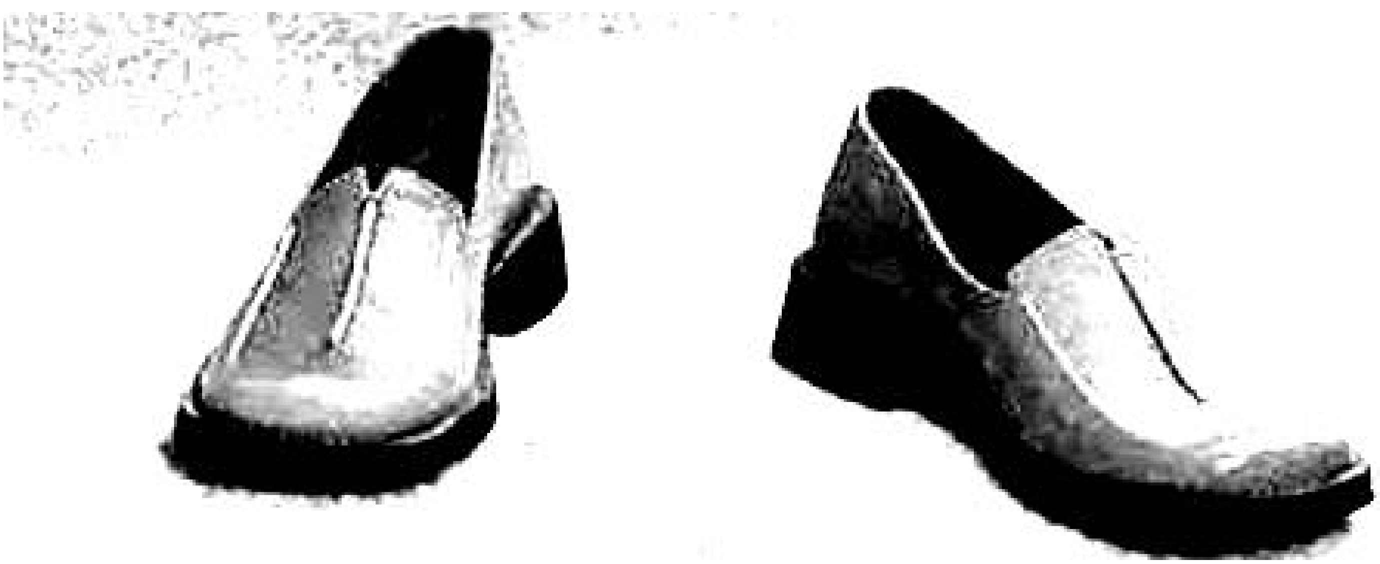

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Note:
This report is among those documents and activities marking the beginning of a new era. An era in which a new vision dawns of customer demand controlling the development of customised Eco-efficient Services with a maximum added value and a minimum environmental load.
This report should be regarded as one of the first careful steps on this new road of challenges and possibilities; steps that will be followed by many more.

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Executive Summary

This report presents a methodology for the design of eco-efficient services. The methodology has two parts. The first is an extension of the familiar five-step product development process to which a preliminary exploration step has been added. This part is a novel approach to help conceptualize the system to be designed. It focuses the design team's attention on three aspects: the device, the institutional or infrastructural context, and on user practices. These three aspects of eco-efficient service are displayed in a Sustainable Systems Triangle to facilitate the conceptualization process. The second part of the methodology is designed to assist the design team during the exploration, policy formulation, and idea finding steps along the overall development pathway. The new methodology is illustrated by a series of cases.

The design of eco-efficient services requires an expended methodology because all three of the sides of the triangle must be involved in all but the simplest cases. It will be a rare event when a single company can bring together all of the parties that must ultimately be involved in the design and realisation process. Much of the expansion of the traditional five-step model results from the need to build diverse teams from the very beginning. In the most ambitious and promising systems, no single firm is likely to have the all the requisite experience and capabilities. This model assumes a more entrepreneurial attitude. The addition of the initial exploration step is designed to assure that all the parties are assembled at an early stage.

The triangular depiction of eco-efficient services is derived from recent research at TUDelft which has looked beyond the traditional staged model of eco-improvement innovations and more clearly delineates what must be considered in the design of innovative systems, the last stage in the older model. It is improvements in each aspect that lead to potential eco-efficiencies. Systems innovations are most attractive as potential contributors to sustainability because improvements related to all three aspects can be combined synergetically.

After an introduction and description of the research project on which this report is based, Chapter 3 presents the case for the development of eco-efficient services, based on an analysis of recent trends. The next chapters present the overall design methodology and a number of illustrative cases, followed by a presentation of the new Sustainable Systems triangle. The last chapter is a short summary and set of recommendations. The appendices contain two sets of cases, one related to the overall methodology and the other to the systems design conceptualization, an overview of barriers and three specific tools.

CONTENTS

Part I DES project, method & tools

1 INTRODUCTION

In the past decade, much experience has been gained with the environmental redesign of products, also called 'ecodesign' (Van Hemel, 1998; Brezet and van Hemel, 1997). Although the environmental benefits of these techniques are beyond dispute, they are insufficient to reach the needed improvement for a truly sustainable society.

In Western economies, a shift has been visible from an industrial economy towards a service economy. Because of the immaterial character of services, this development has been recognised as a potential major opportunity to make substantial progress in sustainability. Several environmental groups across the world regard services as the missing link to reach factor four and higher environmental improvements. To seize this opportunity, it is necessary to map the road towards product-service systems that are more sustainable than current systems.

Some research projects indicate that in principal significant environmental improvement can be possible with Eco-efficient services, which can fulfill functions now carried out by unsustainable product-service systems (Goedkoop et al, 1999; Mont, 1999; Meijkamp, 2000). Building upon the experiences gained in industrial ecodesign projects within the Design for Sustainability (DfS) program, research is now being undertaken to know how, following the environmental design methodology of physical products, functions can be performed more eco-efficiently with the help of these Eco-efficient Services.

The research project "Designing Eco-efficient Services" (DES project) is a collaboration between Delft University of Technology and the Dutch Ministry of Environmental affairs. It is executed by the Design for Sustainability program of the faculty Design, Construction and Production of the Delft University of Technology, and is being conducted in close partnership with the research institute TNO Industry in the centre for sustainable product innovation 'Kathalys'.

We use the term Eco-efficient Services (ES) to indicate that services are central in this concept and that it is important to design them in such a way that optimal eco-efficiency can be established. In other words: functions should be performed with a minimum of environmental impact, use of resources and use of space, while creating maximum added value for the different stakeholders.

This report deals with the question how Eco-efficient Services can be developed to support new business developers and industrial design engineers on their road to sustainability. Its goal is to provide a practical toolbox[1] for both product and service based organisations, which could assist them in their shift towards Eco-efficient services. One of the first steps towards such a 'Designing Eco-efficient Services'- toolbox is the development of a more systematic ES design approach.

[1] The term toolbox is used rather than 'manual' because a manual indicates a fixed dictation of how things should be done. The DfS researchers have the strong feeling however that organisations are best guided by something ever evolving, which is capable of adapting itself to a very dynamic environment, hence the word 'toolbox'.

2 PROJECT SET UP

The various studies that have been conducted on the topic of Eco-efficient Services provide on the one hand an overview of successful ES-cases, usually in retrospect. On the other hand, these studies call for further research, especially for a methodology (Mont, 2000; Clark, 2000). The case descriptions are inspiring for entrepreneurs who are interested in ES, but they do not give an answer to the question how and under what conditions economical and environmental gain can be reached. Since little is known about the exact backgrounds and development methodologies behind the success stories, it is hard to repeat them. The need for the development of an ES methodology that enables service designers and product designers to develop and provide new and current eco-efficient services, is the backbone of this report. Such a methodology can increase the possibility for successful ES-development, through better insight in potential opportunities and barriers, and by the use of methods and techniques to deal with this effectively. Besides, it will become possible for ES-developers to plan the design process systematically, communicate about it within the company and the product-service chain and to get feedback at the end of the developing process.
Once the beginning of a systematic ES-design approach is available, service design consultants, educational and research institutions can take care of a continuous improvement and rapid distribution through their activities. In other words: the development of an ES-design methodology, including factors leading to success or failure, is a condition for further systematic and professional adoption and along with that efficient diffusion of knowledge about eco-efficient services in the society. Rapid dissemination is also essential to gather valuable feedback to ensure a growing and improving methodology.
In this first stage of the research, no distinction has been made between Business to Business markets and Business to Consumer markets. The methodology that should be the result of the research aims to be universally applicable.

2.1 Goal of the research

As mentioned in the introduction, the goal of the project is to design a flexible toolbox which enables organisations to make innovations with a substantial improvement in eco-efficiency. The first step towards this toolbox is the development of a methodology by which ES could be designed. The main questions to be answered by the researchers of DfS during the DES project are:

1. How can Eco-efficient Services be systematically developed?
2. Which tools and techniques are necessary to reach the best result, both economically and ecologically?

2.2 Lay out of the research

Point of departure for the research is an existing Product Development Methodology. More about this existing methodology can be found in paragraph 3.5, Methodological Basics.
The first stage of the research consists of two parts: an empirical and a theoretical analysis. The empirical part has been conducted with the help of case studies. Several ES development projects have been carried out by the Design for Sustainability Program (Oude Elberink, 1998; Flipsen, 2000; Brügemann, 2000; Reijnhoudt, 2000; Meijkamp, 2000; Knot, 2000). Parallel to this, the theoretical research focussed on literature and other research on this subject, besides analysing the characteristics of the case studies (Bijma, 1999, 2000; Bosch, 2000; Van den Hoed, 1998). After the analysis an evaluation took place, the outcome of which constituted the design of a concept ES methodology. The concept ES methodology can then form the starting point for new cases and theoretical evaluation. An overview of the research layout is shown in figure 1.

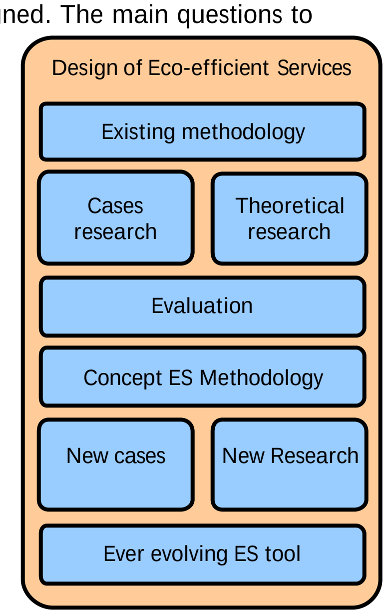

Figure 1: Lay out of the DES project

3 THE CURRENT STATE OF PRODUCT SERVICE SYSTEMS

In chapter 3 the results from the theoretical part are described. Particularly, in the paragraphs 3.1 to 3.3 the background of services in general is being discussed. Paragraph 3.4 deals with function and system innovations, of which Eco-efficient services can be a part. The chapter is closed with explaining the methodology underlying the ES methodology.

3.1 Products and Services

The DES-project has led within the department of Industrial Design Engineering of the Delft University of Technology, to a fundamental discussion about the question: "are services fundamentally different from products?". This question has also been dealt with in studies by, among others, Meijkamp (2000), Bosch (2000), Brügemann (1999), Bijma (2000) and Reijnhoudt (2000), following the research of Mont (2000), Goedkoop (1999), Slob (2000) and Kotler (1994) who engaged in this question before.
It appears from the discussion and literature research that every product has some kind of service aspect and that every service is usually based on the use of several (support) products. As is depicted in figure 2, there is a continuum of products and services with an unclear borderline between them.

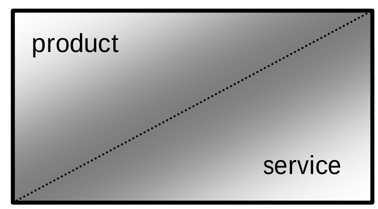

Figure 2: The product service continuum

No TV sets can be sold without a distribution network and shops (whether virtual or real shops), which are services.
No distribution service can exist without trucks, computers and warehouses, which are products.

This is why, in the DES-project, services and products are treated as parts of systems or combinations which are focussed on the fulfilment of demand. These systems are often referred to as Product Service Systems (PSS). A working definition of PSS is:

PSS are "marketable systems of products and services capable of fulfilling a user's demand" (based on Goedkoop and Mont, 2000)

Since all products and services are part of systems, the concept of PSS is not new. What is new is the notion that companies should consider the system their product or service is in when innovating. Some companies have already started to consider the supply chain and end-of-life part of the system, but the new innovation challenge lies particularly in the user system.
When these PSS are consciously developed to contribute to sustainable development; that is with an optimal eco-efficiency as compared to the current situation, we will use the concept Eco-efficient Services (ES). This, by definition, also implies physical products as part of the system.

Eco-efficient services are systems of products and services, which are developed to cause a minimum environmental impact with a maximum added value.

This implies that the development of ES refers to the deliberate development of a new PSS or the redesign of an existing PSS, aiming at a minimum environmental impact per unit of added value. When regarding the graph of figure 3, the aim is to reduce the angle of the vector (environmental load divided by the value). This makes the problem to be solved more complex, because the innovation should involve both axes of the graph. On the one hand the environmental impact needs to be reduced, which is more or less a technical problem. On the other hand the value needs to be increased, which is a

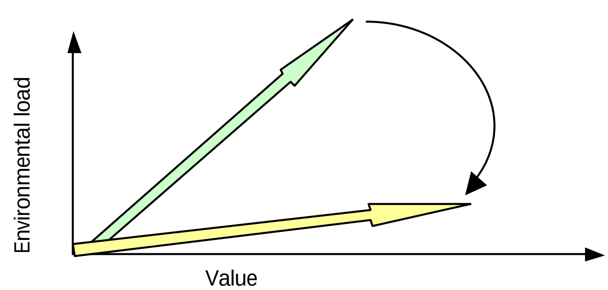

Figure 3: the relation between environmental impact and added value

psychological and social problem. Nevertheless, focussing on both sides will be a more powerful incentive for companies to develop Eco-efficient Services than environmental considerations alone.
Focussing on both sides means the whole system of consumption and production needs to be redesigned, which is at the heart of the ES methodology.

The ES term is introduced (instead of, for example, EPSS: eco-efficient product service systems) in order to stress the service side of product service systems. Researchers believe that an emphasis on services instead of products has the potential to lead to a significantly higher improvement of the eco-efficiency on function and system level. Until now, the environmental focus in product- and service development has been mainly on the physical redesign of products (ecodesign). It was being expected that by giving conscious and systematic attention to PSS as systems, an innovation shift could be facilitated. In principle, this could make considerable bigger improvements in eco-efficiency possible. The consequence is that while designing ES, aspects of services as well as products have to be considered simultaneously. It must be noted however, that services are not automatically more sustainable than products. In every case a careful consideration needs to be made in order to design the package of products and services, which in that particular case is the most sustainable solution.
Given the fact that services and products are both part of systems that aim at fulfilling a customer's need, this does not mean that they are developed in the same way. In table 1 the main differences between service development and product development that came forward from the literature research of the DES project are shown.

Product design	Service design
Long lead time	Short lead time
Is conducted by product developers and technicians	Is conducted by marketers, business administrators and service providers
Hard to adjust to a changing environment	Easy to adjust to a changing environment
Hard technical variables (material, dimensions, etc.)	Soft variables (time, place, etc.)
Secondary products are unimportant for the environmental impact.	Secondary products are essential for the environmental impact.

Table 1 Relative differences between traditional product and service design

Another difference is that product developers can have years of experience with the integration of environmental relevant aspects in their designs, because knowledge and methods have already been developed for this purpose. For service developers, the consideration of environmental aspects is all but common. They have to make up arrears in knowledge and experience.
These differences will be further discussed paragraph 5.3, which deals with barriers.

3.2 Towards a service economy

In Western economies, a shift has been visible from an industrial economy towards a service economy. Three developments in the areas market, technology and business are the main causes for this shift.
First of all the market side has been changing, by demanding more and more customised solutions. This means in practice that businesses offer flexible packages of products and services, which can be designed to meet a certain need. This is also referred to as 'mass customisation'. Especially in mature markets, services can be the key to add value and diversification (Oppedijk van Veen, 2000). Besides, services offer product based companies a way to get closer to their customers and build a relationship with them.
On the other hand are the developments in the Information and Communication industry, which expand the possibilities for dematerialization enormously. Added value is not only generated by physical products, but increasingly by intangible service elements (Nijhuis, 2000).
Finally, western companies tend to specialise more and more. They go back to their core business and everything else is outsourced. This means that services that used to be internal and part of the production process now become explicit. This has caused an explosion of new service companies, specialised on business to business delivery (De Jong, 2000). In Business to Business industry the shift towards integrated, customised product service systems is already happening for several years.

3.3 *How to measure environmental impact of Services?*

Pure –dematerialized- services as such have –in theory- no environmental impact. At the most, they consume human energy, but not more. However, services always depend on support products, which –as PSS- do cause environmental burden.

Example 1:
The service 'teaching' as such has no environmental impact. But regarding the system around 'teaching', pupils and teacher use a mode of transport to get together, they use books and a lighted and heated building. These tangible products that support the intangible service cause the environmental impact of the complete product service system.

Example 2:
When two friends take a walk in the park and one friend advises the other on a certain issue, this could be regarded as a service. The environmental impact of this service is zero. However, the person having the problem could also hire a professional consultant. Immediately, products are involved bringing along their environmental load. The consultant visits with a car, calls with a telephone, uses the elevator, types on a computer, has an office and writes reports on paper. The service has now economic value, but also environmental burden.

In order to determine the environmental impact of a product service system, one should determine the environmental impact of all the products used in the system. Although tools already exist to do this, it is more complicated than it seems.
The problem is to determine what products are in what proportion part of the system. To do this, system boundaries need to be determined.
Measuring environmental impact is done in order to be able to compare the old system with the new one. This should be kept in mind when determining the system borders. The old and new system should have the same functionality.

Example:
In the car sharing case an environmental assessment has been made with two different functional units, a limited one and an expanded one. With the limited functional unit, only one kilometre with an owned car has been compared with one kilometre in a shared car. This neglects changes in consumer behaviour. The expanded functional unit concerned the total mobility of a household during one year, before and after adopting the car sharing service. This calculation did consider changes in consumer behaviour.
That the choice of functional unit strongly influences the outcome of the calculation is demonstrated by the fact that the calculation with the limited functional unit yielded an improvement of 14%, while the expanded comparison led to an improvement of 22%, or even 40% when compared with the mobility of an average household.

Or, as Bras-Klapwijk (2000) puts it: The functional unit should be defined in such a way that it can account for changes in volumes of products and processes that are needed per person per year. Instead of a certain quantity of product, the functional unit should refer to an abstract function, like being clothed or having mobility, and to a period of time. Needless to say: the wider the system boundaries the more complex and time consuming the calculation will be.
Due to the important role of support products like roads, cars and computers, which often could be neglected when analysing only products, it could be necessary to develop tools that are developed especially for services. These could be based on the same LCA techniques that are used with products. These tools should address specifically the way to determine system boundaries and calculate the contribution of support products to a product service system. In appendix C a concept of such a tool is discussed.
Another complicating aspect of the analysis of systems is the so-called 'rebound effect'. Rebounds are negative side effects that cancel out the main goal. These effects are hard to measure because rebounds can take place outside the considered system and concern human behaviour patterns.
Vogtländer (1999) has developed a calculation method to assess complex systems of products and services. He takes ecological as well as economical parameters into account which eventually is visualised in the EVR graph. An example of such a graph is shown in figure 4.

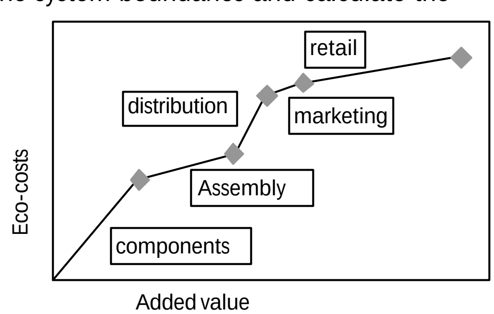

Figure 4: An example of EVR graph

3.4 Function and system innovation

In figure 5 an often quoted graph is shown that positiones Eco-efficient services as a logical continuation of the road already travelled with ecodesign of products (type 2), since they are part of the type 3 curve: ‘Function innovation’ and sometimes even of type 4 ‘System innovation’. It is being assumed, following the time axis, that it’s more difficult to create whole systems changes, including the establishment of new cultures and infrastructures, than product and process redesigns. Also the type 3 and 4 function and system innovation approaches, like ES, are supposed to have the best eco-efficiency potential.

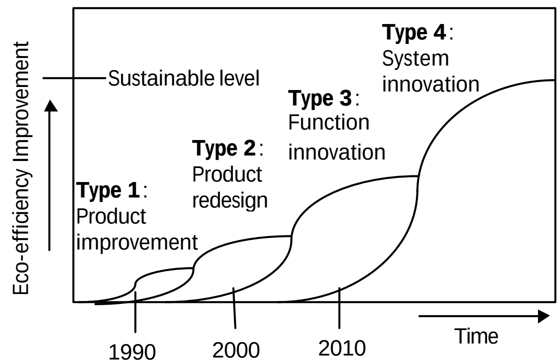

Figure 5: Eco-efficiency curves

3.5 Methodological basics

Now we know the differences between products and services, it is time to focus on their similarities. After all, we are looking for a way to develop Eco-efficient services in which services and products can be equally represented.
When products or services are developed or redesigned, this means a company is innovating. They both aim at fulfilling a need from the market with the ultimate purpose of making profit. For product development a much used methodology is the product development process of Roozenburg and Eekels. This is an extensively described process, of which an outline is shown in figure 6. (Roozenburg, 1998).

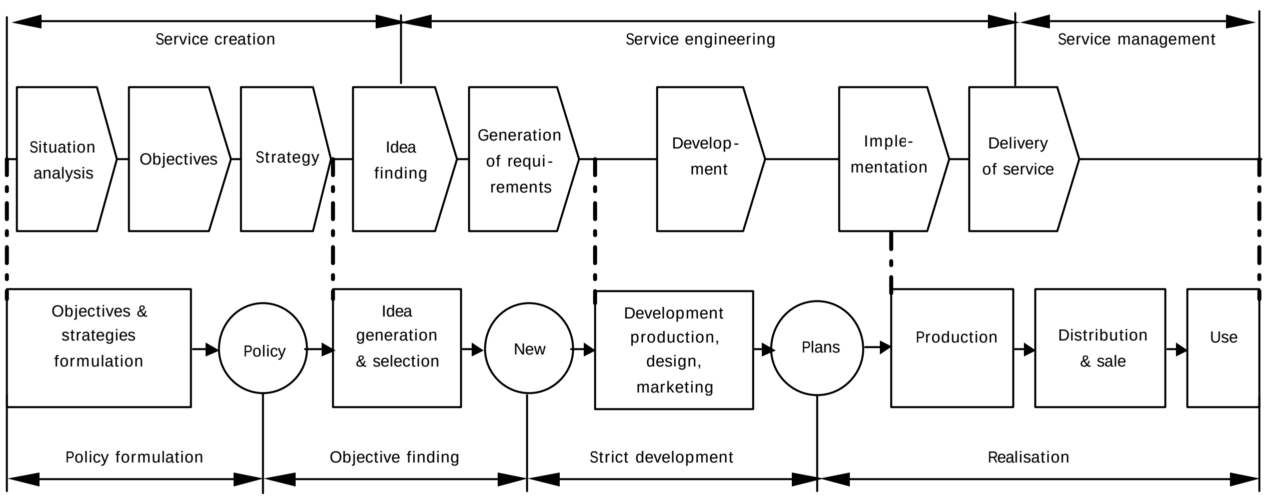

Figure 6: The product development process of Roozenburg and Eekels (1998)

Research has shown that methodologies for product and service development are quite comparable. In figure 7 the Roozenburg methodology is compared with a service development methodology based on BMBF and Müller. (Brügemann, 2000)

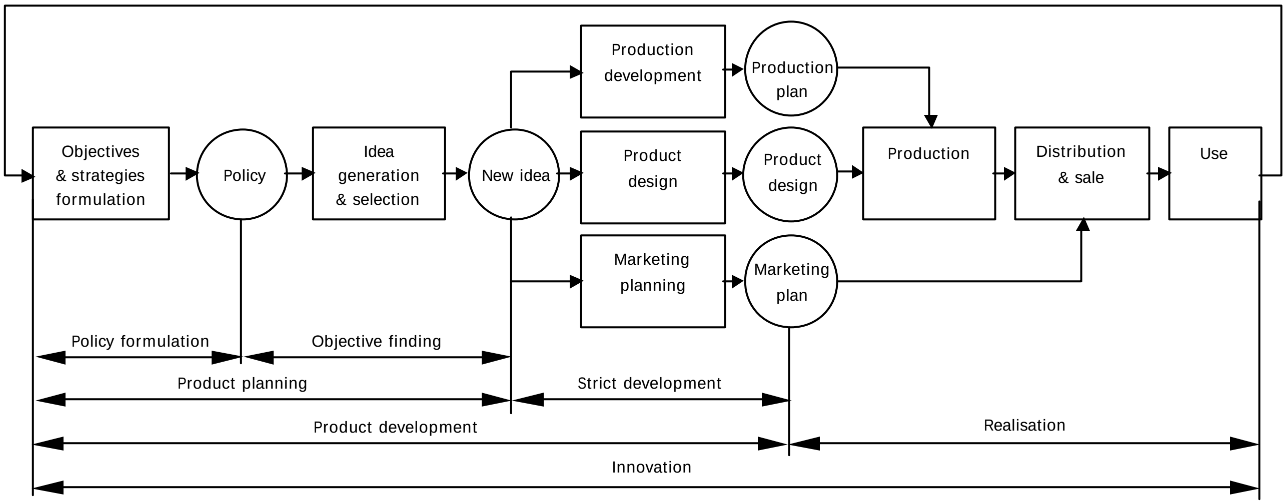

Figure 7: The product development process compared with the service development process.

As the product development methodology is based on the structure of innovating processes, we expect that it is applicable for eco-efficient product services too, and use this as a point of departure for the development of a methodology for the design of Eco-efficient Services.

4 DEVELOPING AN OVERALL DEVELOPMENT PROCESS

The findings from the previous chapters lead to the expectation that for the development of an ES-methodology, much of the existing product design basics and environmental tools are applicable, but need to be adapted. Because many Product Service Systems are unique, it is not the intention to supply a strict guideline on how ES should be developed but to assist decision makers with a structure, suggested actions and tools.
A special point of attention is the complex initiation phase, which is not represented in the model of Roozenburg and Eekels.
A first description of the ES-process to be followed is given in this chapter, which should be regarded as a draft methodology that will evolve in the follow up of the DES project.
In chapter 5, the results from a preliminary test of this methodology in a number of cases are being given.

4.1 DES methodology

In this paragraph the draft ES development process is discussed per phase, following figure 8. This process is a framework of activities, rules of thumb and tools that enable people to develop ES. Much of these activities and tools still need to be filled in. As mentioned before, the real process is never linear, like in the figure. Sometimes it is necessary to jump back and forth between stages or to repeat stages more than once. Nevertheless this process can be used as a framework to structure and communicate the different activities that in the end should lead to a successful Eco-efficient Service.

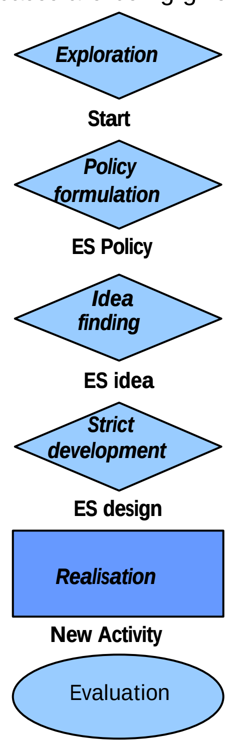

Figure 8: the DES project

STEP 1: EXPLORATION

In this phase, which has been added to the phases of the process of Roozenburg and Eekels, one person, company or institute gets the idea for a function or system level innovation and makes sustainability part of this innovation. Especially with system innovations, it can be necessary to form coalitions of companies and stakeholder groups or new businesses are set up (see paragraph 5.2). Therefore, relevant companies and groups need to be identified and approached by the initiator. As with product innovation an innovation champion within the company increases the chances for success. When dealing with more than one company, every participant should have his own innovation champion.
It is important to identify the drivers for innovations. These may not be the same for all partners involved. One of the drivers can be 'becoming more sustainable' but this is not necessarily so. The innovations will in most cases also have to lead towards other benefits, like increased market share, better image or competitive advantage. In this phase the scope of the innovation, or in other words the system that will be changed is very broadly defined. If possible, future users should be identified and it must be decided if and how they will be involved in the process.

Actions

- Form a project team of companies, departments and other partners that together have the knowledge and means at their disposal to develop a successful ES, or start a new company with the relevant resources.
- Appoint a project manager.
- Formulate a vision and goals.
- Determine the system that will be the 'playing field' of the project team.
- Make an analysis of the current situation.
- Assess the environmental load and the economical value of the system that will be innovated if you wish to base your policy on this information. It is also possible to make a comparative analysis later in the process.
- Identify future users.

Tools

- Market research tools (mostly qualitative).
- Strategy and policy tools, like the SWOT analysis (SWOT = Strengths, Weaknesses, Opportunities, Threats).
- Network management tools.
- META, a new tool, with which a qualitative, quick environmental assessment of a product service system is possible. (See Annex C)
- ViP scenario approach: to be used for companies and designers that are fixed on existing products and solutions. The approach offers the development of a new product or product-service vision by envisagening the future context, the interactions with the user and by making the implicit designers' choices explicit. Within the DES project the ViP approach has resulted in unexpected product and service related solutions (See Appendix E).
- Benchmarking, which stands for comparing services with the same functionality from the perspective of quality, costs, environmental load, etc..
- Backcasting, looking back from future sustainable scenarios to today's system, thereby identifying key factors, actors and technologies for change (Vergragt, 2000).

Results

- A business coalition/new business.
- A team with a mission.
- A project plan.
- A description of the system within which the innovation should take place.

STEP 2: POLICY FORMULATION

During policy formulation, goals and strategies are defined in a policy. This policy should give direction to the subsequent phases. When a network of companies is involved in the ES development, joint and individual goals need to be formulated and the contribution of every participant needs to be specified in time, money and tasks. However, even when it is an internal project of only one company different departments need to participate for which it is also necessary to formulate goals and specific tasks. Furthermore, the central management of the project has to be arranged.

Part of the goals should be the intention to end up with an eco-efficient service. Also, the desired balance between products and services must be indicated. Furthermore, the targets concerning market share, profits and sustainability will be indicated. It must be noted that the vision formulated by the partners in this phase, is determining the level of sustainability, which might be reached. A company focus, for example, limits the scope of the innovation and therefore the possible environmental gain.

When a certain environmental gain compared to the current situation is the goal of the project, it is necessary to analyse the environmental impact of the current situation. This can also be done at the end of the process, but when done during policy formulation it can be helpful input to set goals by identifying bottlenecks in the current solution.

Actions

- Set more specific goals than the global ones formulated in Step 1. Indicate the direction of the innovation.
- Determine the roles of the partners and external groups.
- Create an atmosphere of trust and openness between the partners.
- Specify budget and tasks.
- Make a time schedule with milestones.
- Refine the project plan with the ES policy in it.
- Determine what knowledge is needed and if this knowledge should be involved in the form of participating partners or should be purchased.
- Develop a first list of requirements.

Tools

- ViP approach. See Appendix E.
- Adapted ecodesign tools.

- LCA scenarios.
- META matrix. See Appendix C.
- Project management tools (planning, flowcharts, budgeting etc).
- External analysis. To identify the customer need and external opportunities and threats.
- Internal analysis. Examine the strengths and weaknesses of the company or companies.
- Stakeholder analysis.
- Benchmarking.

Results
- A policy which at least contains the statement that the outcome of the project will be an Eco-efficient Service.
- Time schedule.

STEP 3: IDEA FINDING

Idea finding is a bit odd name for this phase, because in reality, the whole process starts with an idea, and more ideas are generated in every phase. This 'Idea finding' phase however, aims at translating rather vague and broad ideas in concrete ES ideas.
The most important change in comparison with traditional product and service development in this phase, is that it is necessary to think in terms of functions and customer demand instead of products. This abstract level on which ideas need to be generated makes this phase more complicated.
The Idea Finding phase often starts with some kind of problem definition that needs to be solved by the ES to be designed.
The techniques that are used in product development, to go from a policy to a design goal, are for the most part also suitable for idea finding for an ES, for example internal and external analysis. However the way the tools are applied in a multi actor project may differ from the traditional way they were used.

Actions
- Define accurate problem definition.
- Refine the list of requirements.
- Generate ideas with the project team.
- Select one or more ideas to be further developed.
- If necessary, start sub-processes with participants or future suppliers.

Tools
- More expanded External analysis, especially among future users.
- Second Internal analysis. Examine the relevant strengths and weaknesses of the company or companies to specify their tasks.
- Creativity techniques to generate ideas.
- 'Blueprinting', when an existing service is being redesigned or replaced. Blueprinting is a method to describe a service in the same way as a product with the help of a process tree, can be a suitable tool to obtain insight in the visible and invisible elements of a service. See appendix D.
- ViP approach. See Appendix E.
- META-matrix. See appendix C.
- Adapted LiDS-wheel, both for generating ideas and for selecting them on environmental terms. (Still needs to be developed; more information on the LiDS-wheel for products, See Brezet & van Hemel, 1997)).
- Green options generation.
- Benchmarking.
- Ecocosts/value approach, EVR (Vogtländer, 1999).

Results

The result of this phase is a design brief. First ideas are generated (divergence), then a selection will be made based on certain criteria (convergence). In the design assignment the most important requirements are specified and which products and services should be part of the ES. In the case of a product service combination the design brief need not necessarily go to one person or department. It could for example be possible that the service part is developed within the company, but products are purchased elsewhere, or vice versa, depending on the present know-how of the company. In case of a network of companies this is the point at which each company will start to go through their own sub development process.

STEP 4: STRICT DEVELOPMENT (DESIGN)

In this phase, the design brief has to be developed into a detailed and feasible design for the new ES. All variables that determine the products and services forming the ES have to be considered, besides the production of both elements and their marketing. It is in Strict Development that the differences between service and product development (as discussed in paragraph 3.1) are most visible. Because of these different aspects of PSS, the development of both needs to be carefully planned, especially because they influence each other's characteristics.

Actions

- Define every variable. For the involved products their specifications and for the services their protocols of executions.
- Make an assessment of the prototype.
- Check if the ES complies with the list of requirements.
- Before one starts with the next phase, it is recommended to test the design, so when necessary, adjustments can be made before the ES is being marketed.
- Have regular meetings with all people involved in designing the different parts of the system.

Tools

- Eco-purchase, a checklist aiming at the environmental aspects of the purchase of materials, components, products, goods etc., that will be part of the new ES system.
- LCA scenarios.
- EVR (Ecocosts Value Ratio).
- Adapted LiDS (under development)
- Blueprinting. See Appendix D.

STEP 5: REALISATION

During realisation, the product components will be produced and all preparations to execute the service part (which is produced at the same time as it is consumed) are made. These preparations can range from the programming of a website, to organising a location, to training staff.
When all this is done, the ES can be introduced on the market place.

Actions

- Communicate the new ES to the market.
- Produce or purchase the necessary products.
- Hire staff.
- Maintain the service. (manage time, place and people)
- Sell the ES.

Tools

- EVR (See step 3).
- 'Green' communication: guidelines on the specific promotion of the ES.
- LCA scenarios.
- Distribution design.

Results

The result of this phase is an Eco-efficient Service, which is sold on the market.

STEP 6: EVALUATION

It is very important that in this last phase an evaluation is built in, in order to guarantee a process of continuous improvement.

Actions

- Monitor market response.
- Measure the environmental impact of the new system and compare with the old system.
- Measure financial effects for the involved companies.
- Evaluate project process.
- Write final report.

Tools

- EVR (See step 3).
- Financial tools.
- LCA analysis of the new ES.

Results

The project should end with a Final report, including the environmental and economical effects.

5 RESULTS FROM THE CASES

The main selection criteria for the cases have been diversity in function fulfilment and learning opportunities. These learning opportunities are reflected in the fact that the researchers have been involved from the beginning as co-developers which makes it possible to closely follow the progress of the projects. Furthermore, the Delft University of Technology and Kathalys have had the opportunity to supply and test knowledge and experience in these projects (the “reflective praxis” research approach).
The majority of the projects concern the development of a new ES, while one case concerns the redesign of an existing product service system. See Table 2.

The ultimate goal of every initiated experiment is to launch a commercially successful ES, which replaces a non sustainable system on the marketplace. However, failures are permitted in this experimental stage, so we can learn from the mistakes for the next cases. After all, with traditional product innovation, only about one out of 25 original ideas ends up effectively at the marketplace.
Except with the Car Sharing case, which finds itself in the market stage for a period of time, the DES-research team is still involved in the further development of these ES-projects.
The cases have been conducted in different fields of business that can be summarised as Mobility, Household and Work.
The descriptions of the cases can be found in appendix A.

	New Service Design	Redesign of an Existing Service
Mobility	Car Sharing	Mobility plan Texel
	Individual Transport on Short Distances	
Household	Upgradable oven	
	Outsourcing of clothing care	
Work	Office furnishing	

Table 2: The cases that have been studied in the DES project.

Considering the limited amount of cases, the findings have an indicative character. At this point, further external verification, analysis and continuing experiments still have to take place.

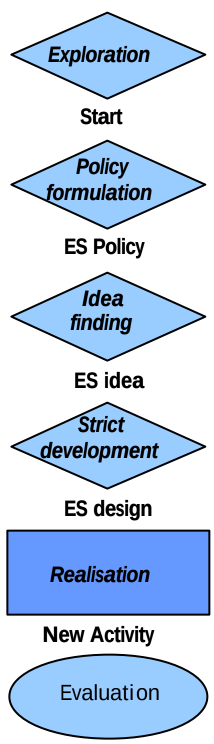

Figure 9: the development process of the cases

5.1 Development Process

Bosch (2000) has investigated the development processes of each ES case and concluded that every case can be described with the stages of the Roozenburg and Eekels methodology, as depicted in figure 6 in chapter 3. The differences are visible in the activities within the stages and the tools that are used with these activities.
Furthermore it is necessary to add a stage before the real start of the project which can be described as an explorative stage. In figure 9, the phases of the methodology are depicted, expanded with this explorative stage. This stage is crucial for the subsequent development stages, because there is not yet a vision, but only a preliminary idea that *might* be in the direction of ES. The business vision will have to be developed first by the initiators of the idea and sometimes it is necessary to start up a new business entity or form coalitions with other businesses. More about these coalitions can be found in paragraph 5.2.
A possibility to change a system is the foundation of a new company, whether by new entrepreneurs or by existing businesses. Especially in the rapidly changing ICT world, young new businesses are capable of realising radical system changes by inventing new techniques or services.
Below an example is shown of the explorative stage from one of the cases.

One of the first activities in the Clothing Care case was the searching, selecting, and convincing of relevant stakeholders. With a broad group of stakeholders ideas were generated in a workshop setting. These ideas were later developed into scenarios which contained products as well as services. Per scenario a new group of relevant stakeholders was formed which would develop these scenarios further. This could be seen as the start of the policy formulation phase of figure 6.

The diamonds shape of the phases symbolises the diverging and converging character of the activities conducted in each phase.
It must be noted that the model of figure 6 is an extreme simplification of reality. ES development can be a very complex process in which one goes rarely as linear through the phases as suggested in the model. All thinkable jumps, interactions and iterations are possible. Besides, a decision making process is never completely rational. Former experiences, personal preferences and other unconscious factors are influential elements as well. The model functions as a guide and a means to structure the complex collection of actions within the process and to communicate it to others. This is also why such a model of a methodology is a good starting point to create a toolbox for organisations.

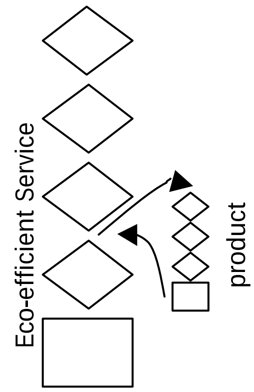

Figure 10: Development process of an ES with sub-process.

It is possible, that while going through the process of developing an Eco-efficient Service, one or more sub-processes are needed. This can be the case when a company outsources a part of the project for which it has not got the expertise. With the upgradable oven case the project was initiated, managed and developed by the service department. It was necessary however, to give the design assignment for the physical product (the oven) to the design department. Such a sub-process has been graphically depicted in figure 10.

5.2 Business coalitions

The upgradable oven case is an example of the development of an Eco-efficient Service within one company. This company has its own service department, so much of the needed expertise is present. However, the company management restricted the innovation space in principle to the mere adding of a service. System innovations however, are rarely done by one company alone. Chances of success increase when a network of businesses, which together cover an entire system, work together. Changing the mobility concept of the isle of Texel, for example, is only possible if all mobility businesses participate. The bus company or ferry company could never pull off such an innovation by itself. See appendix A for a further description of the case.
Forming such a coalition of businesses to go through an innovation process together has many consequences for the process. Many forms of collaboration between companies exist. It is possible for example that the partners start the process together, but separate during the ‘strict development’ phase, so each partner can develop a part of the system. See figure 11. In this particular process every company uses its specific knowledge to develop a certain part of the ES. The first and last phases however, are completed together.
In the Texel case a plan was designed by the project team in which all the partners were represented. The team conducted the first three phases of the process. When the ‘strict development’ phase begins, every mobility partner needs to make the proper design changes in its part of the system. During this phase the partners need to discuss their progress and at the end of the phase create a working system from the parts.
Collaboration between companies can also take the form of supplier-buyer relationships. One company takes the lead in the innovation project but outsources those parts of which it has insufficient knowledge and means.

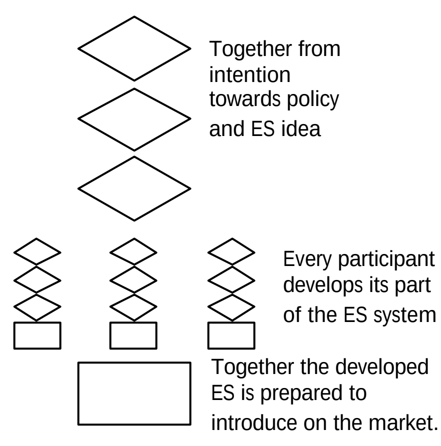

Figure 11: Development of an Eco-efficient Service with a business coalition.

As a consequence, ES design requires a strong training in planning and controlling techniques, because parallel sub-processes lead to more complexity.

Badly organised and controlled networks of companies can stagnate an ES-project. To avoid this, special planning and network management know-how is necessary, also from the side of the involved researchers and developers. To keep the participants together and to synchronise the goals is a job in itself.
To build up a new business coalition from the explorative stage requires some special conditions that have been investigated in the DES project. These conditions are listed below (Van den Hoed, 1999; Bosch, 2000; Knot, 2000).

- Different visions, expectations and interests of involved parties will have to approach one another after some time, so when needed clarity can be gained, for example to control agreements about financial contributions and project responsibilities;
- Commitment of partners and representation from a suitable business level (as to knowledge, decision authority, involvement);
- An adequate – not too high, not too low – level of innovation ambition. It has to be avoided to accumulate too much technological innovations in one new concept, while trying to go beyond just an incremental step;
- Anticipate opposition that could be crucial for the implementation of the ES. A stakeholder analysis can be a solution, as long as this does not mean that current stakeholders can control or stop the ES development just because of existing interests;
- A realistic assessment of new technology options**.** Often ICT and emerging technologies like fuel cell technology are part of the envisaged future ES, for instance to improve the communication, logistics and emission profiles within mobility systems. However, it should be realized that these new technologies require their own, new production, energy and distribution infrastructures, that should be taken into account when calculating the eco-efficiency advantages of ES designs. (See for instance Huiberts, 2001, for an estimation of the future energy use for ICT-services in the Netherlands);
- Sufficient involvement of future or current users: in the examined cases Car Sharing and Office furniture, users are co-designers of the service. With the Clothing and Upgradable oven projects, special techniques have been used to identify future consumer needs. In the mobility plan of Texel, only the current users have been limitedly involved;
- Proper judgement of each others complementary strengths;
- Correct timing of the coalition formation, especially the coming forward of a business leader;
- Create an atmosphere of trust and openness among the partners.

5.3 Barriers

To follow the ES development process means meeting different barriers than with ‘standard’ product development. Considering this, new solutions will have to be sought and applied. In the previous paragraph already some barriers have been discussed that are specific for business coalitions.
Other main barriers that are new compared to traditional product development (Bosch, 2000) are:

- The idea generation phase can be more complex when innovating at function or system level, because the ideas need to be found on a higher level of abstraction (not ‘design an artefact for transportation’ but ‘design a new mobility concept’). On the other hand a broader design space can invoke more creativity and radical new ideas.
- The transition from idea to design. It can be hard to translate the new ideas in concrete ES ideas and short term strategies. The phase of strict development no longer consists of one product, but of a combination of products and services, which can be completely different from the current situation. The requirements for each of the elements have to be known, as well as which part of the functionality will be fulfilled by services and which part by products, before one can start with the strict development phase (see figure 6).
- The parallel development of different elements. The characteristics of the product elements can influence the service elements of the ES and vice versa. This requires extra attention from the management of the complete innovation project, because the two different elements do not have the same lead time.
- The policy needs to be formulated much more extensively than for product development. Already in the phase of policy formulation it has to be clear which players participate and what their role will be. Also a detailed time schedule and the filling of possible knowledge gaps should be part of the policy. This does not mean that the stakeholder group can not change during the process but this should be accounted for at the start of the project. Participating in the first few phases of the project for example could be with less obligation then participating in the implementation phase.

- Existing companies will have trouble with radical innovations because they will have to change their complete company structure and culture or start a new business that could be a competitor to the existing one.

For a more extensive list of possible new barriers, see also the barriers and solutions table in Appendix B.

5.4 Opportunities besides environmental ones

Because most cases are still in development, the non-environmental benefits are not yet entirely clear.
As far as the added value side of Eco-efficiency is regarded, in all cases a significant increase has been determined. The studied ES-cases are in principal interesting for new business and offer a potential profit perspective. Apparently, this business perspective seems to be the most important drive for ES-development in four of the six cases.
The economical, technical, and social trends mentioned in paragraph 3.2 offer some major opportunities for existing and new businesses developing ES.
Furthermore, when these services are developed consciously of the environment, the company can use the Eco-efficient Services to create an image as “responsible company”. This is the case for example, with the companies that offer car sharing. They emphasise the ecological benefits of their service in their communications.

5.5 Environmental gain

The overall international expectation is that Eco-efficient services have the potential to lead to significant improvements in environmental impact. Table 3 shows that with the investigated cases the environmental gain varies strongly. This has to do with the much varying nature of the cases, but also with measuring methods. The choice of system boundaries and measuring method influence the outcome of the calculation. In every case researchers had to invent their own measuring method, although they all used LCA based tools. As long as there is no unambiguous measuring method for complex product service systems, the outcome of calculations cannot be compared to one another unambiguously.

Cases	Environmental Gain	Benefit
Office Furniture	25-30%	Less use of paper and space
Car Sharing	40%	Decreased use of cars
Upgradable Oven	5-16%	Extension of economical life span
Outsourcing of Clothing Care	Potentially up to 95%	Less use of textile, detergents, water and energy
Mobility Texel	30%	Less use of cars
Individual Transport on Short Distances	3%	Less use of cars.

Table 3: Environmental gain of the cases.

However, in spite of the variety of the research output, three important conclusions can be made.
First of all, it seems that the more extensive the system is to be innovated, the better the environmental improvement. For example, the upgradable oven and individual transport cases were only service added products. This means a service was designed that could be added to an existing product. The changed system was envisaged to be quite limited. If the complete kitchen or house-to-work mobility was innovated, the environmental improvement could have estimated to be much higher. Another example can be found in the Clothing care case. The scenarios designed for the complete clothing system have a much better environmental gain then the scenarios only dealing with the washing of clothing. (Bras-Klapwijk, 2000).
Secondly, the environmental improvement depends on market penetration. If for example, the office furniture service is used by only a handful of clients, the environmental gain will be limited. Naturally the more clients use the Eco-efficient Service, the better the possibilities for significant environmental improvements.
Finally, the way customers react to the Eco-efficient Service is determining the size of the environmental gain. With the car sharing case there were customers participating in the Car Sharing program instead of buying a car. This, of course, means a good environmental score. On the other hand however, there were customers joining to have a second car at hand, one they could otherwise not afford. This example shows

that eventually it is customer behaviour that is one of the most important factors determining the environmental improvements. That is why system innovations should aim at changing unsustainable consumption patterns. Unfortunately, consumer behaviour is also the factor that is hardest to predict and to measure.

5.6 Use of tools

The cases show that many of the in Ecodesign common eco-concepts and tools are applicable, but there is a different user and infrastructure context.

For example LCA cannot always be applied in accordance with the ISO-standard, LCA scenarios are needed that can compare one ES-system to another without having exactly the same functionality. In the Clothing case, not the environmental effects were calculated, but system related indicators, such as the amount of textiles, energy, clothing waste, washing equipment, detergents etc (Bras-Klapwijk, 2000). Furthermore, an instrument like the MET matrix can still be applied, but has to include ‘support goods’ and ‘production of physical infrastructure’, which can determine the environmental impact of ES. Benchmarking and the LiDS wheel (See Brezet & van Hemel, 1997) can be useful applied in adapted form.

It is clear that development of additional tools is necessary, especially to assess the environmental impact of Product Service Systems and to find improvement strategies. Bijma (2000) has already conducted preliminary research into such tools. An example of an adapted MET matrix is discussed in appendix C.

Part II Review and Future

6 THE SUSTAINABLE SYSTEMS TRIANGLE

The DES project should be considered to be a first experiment for the development of a design methodology for eco-eco-efficient product-services systems. More "reflective praxis" projects will be needed, amongst others focussing on the potential differences between consumer oriented and business-to-business services.
Before formulating elements for the further ES-research agenda, a reflection on the findings from the DES project is appropriate. As a consequence, we will recommend future sustainable systems designers (both industrial designers as new business developers) to take into account, next to several practical ecodesign and ES-tools, the concept of the sustainable systems triangle (SST) as a potential guidance.

Looking back at the DES project and other ES case studies, Ehrenfeld & Brezet (2001) make several observations, to take into account in further ES experiments. Points for discussion are:

I. eco-efficient services vs. products as discriminating notions;
II. eco-innovation as a process with a natural progression;
III. the humanistic side of eco-innovation.

ad I. Rethinking the notions of products and services.

Much current literature and emerging policy discussion has the general theme of a shift from products to services (Heiskanen and Jalas, 2000. Mont, 1999. White et al., 1999. Stahel, 2000). The impression that a reader gets from this literature is that products are substantially different from services. We argue below that these two categories are merely different modes of delivering satisfaction and that the dichotomy established in much of the current literature clouds the basic design issues involved in the more important goal of finding more sustainable ways to satisfy demand. It is not the difference between product and service, but the design of the artefact, its institutional (or infrastructural) context, and the consumers' practices-in-use that are the critical factors determining its effectiveness in promoting sustainability.
Manufacturing processes produce artefacts that are then purchased and used ultimately to satisfy consumers. These goods are artefactual or material in nature and we shall refer to them as products which term is more familiar in the design community. (Normann, 1984) Products are artefacts purchased by actors in anticipation of future service, even if they are used soon after the acquisition. Services, an alternate mode of satisfying demand, are immaterial in nature (Mont, 1999. W. Stahel, 2000. R. Normann, 1984). Services are consumed right away.
The apparent category difference of products and services has its roots in economic conventions where market transactions have been divided, for convenience in keeping accounts straight, into goods (products) and services. For goods, satisfaction follows after the market transaction and may be a single event, for example eating the food brought home from the supermarket, or continuing events, like commuting every day in the automobile purchased or leased from the dealer, or continuously enjoying the comfort of a carpet on the floor. Services have a different temporality that we argue is the primary and constitutive aspect differentiating products and services. Services are consumed at or very near the time of the market transaction. Both forms of satisfaction involve both actors and artefacts and both involve some sort of infrastructure (or institutional arrangement) in which the products and services are provided and subsequently consumed. Consumption is equivalent to the actions that produce satisfaction. Thus we argue that the very notion of product-service systems, as different from either products or services is misleading as both products and services, as conventionally denoted, produce satisfaction within a system of actors and other artefacts.
The number of terms in use is large and confusing as shown in the following list. (original citations in: (Heiskanen and Jalas, 2000) and (Mont, 1999))

- Non-material services
- Dematerialized services
- Eco-efficient services
- Product-life-extension (services)
- Product use services
- Product oriented services
- Need-oriented services
- Demand services
- Results-oriented services
- Product-based services

Confusion between products and services is further complicated by the terminology of the Wuppertal Institute where products are defined as "service-producing machines." (Schmidt-Bleek, 1994) We prefer to use a different distinction, satisfying, that avoids the confusion of terms in much of the emergent literature on products, services, and sustainability. Human beings are actors spending most of the time seeking satisfaction (completion or perfection) by pursuing intentional goals. Our days are spent in practices that are so familiar that we do not think about them as we practice them. (Heidegger, 1962. Giddens, 1984) As we satisfy our intentions in one domain of our concerns about living, we move to another and so and on. In order to achieve satisfaction, we either pick up an artefact we 'own' and use it or ask some other human being or artefact to do something that is satisfying. The only difference in these two modes is whether we do the work involved or it is done by another person or machine we do not "own." There are no "products" or "services" involved, only action in which artefacts or other people are involved. There is a clear instrumental character to the artefacts-in-use.

Both modes of satisfying are encountered in everyday life, as illustrated in the next examples.

Example 1
The most common way of commuting to work in the United States is via one's own car (the product). The actor drives the car to work. He or she is active in this role and the artefact's meaning as a "car" is constituted by and within the action in which it is being used. It is nothing but a pile of stuff otherwise. On the other hand, should the commuter's car be unavailable, he or she can call a taxi and ride in it to work (service). The actor in the second scenario is passive in this mode of satisfaction and during the passage from home to work could be said to be inactive. Technologically, little, if anything, is different. Identical models of vehicles might be employed. The intention is virtually identical.

If we look at other examples of what are conventionally considered to be services, we often, maybe always, find that the transaction between actor and service provider is aimed at providing immediate satisfaction. On the other hand, when we look at market transactions involving goods (artefacts), most of the time the artefacts are acquired for future use.

Example 2
When one buys food in a supermarket, she is obtaining an artefact (product) she will use in the future to satisfy her hunger. But when one goes to a restaurant (service), he seeks immediate satisfaction for the same concern. There may also be other intentions present that lead to the choice of one mode of satisfaction over the other, for example, wanting to be seen in the latest high-fashion bistro. When we act, we aim to be satisfied in some domain of concern, and we will choose the means according to other criteria depending on the moment. Artefacts are always involved, whether we own them or acquire their services through other arrangements. In the back of the restaurant, the chef is using a stove, food processor and other tools just as we might at home.

Although the product/service distinction is important to economists, it may not be as important to designers of artefacts and the satisfaction-delivery system in which they are embedded. At the risk of introducing yet another terminology, we will speak of **sustainable satisfaction-delivery systems** at the target of our analysis. And although we claim that 'products' are always used in some system, **we will refer to products conventionally as artefacts** that show up at the end of some manufacturing process and have been brought to the market.

The key distinctions that emerge from this abbreviated discussion of human behavior are issues of ownership and the temporality of acquisition. Satisfaction can be obtained either by using a product previously acquired (self-satisfaction) or via a transaction in which satisfaction is obtained contemporaneously from other actors and the equipment they own. Preferences for the choice of one or the other of these modes of satisfaction are buried in the consumer's cognitive system and are influenced by many factors outside of the immediate acts of satisfaction. **This basic preference between self-satisfaction and conventional market-based services is important in designing sustainable satisfaction delivery systems.** It is not the case that consumers naturally prefer one mode over another.

ad II. Innovation for sustainable satisfaction-delivery systems.

The significance of this analysis, so far, is that consumers always seek satisfaction whether via 'products' or 'services'. There is less basic difference as claimed by many. The significant ontological distinction is in the different temporality of satisfaction between the two categories. Other practical differences are connected to ownership and potential technological differences between products for self-satisfaction and functionally equivalent equipment used by service providers. **Designers of sustainable satisfaction-delivery systems need to focus on the particulars of the system rather than assume that one mode is always or even generally better than the other.**

Similarly, designers should be critical of claims that there is a natural progressive hierarchy to innovations in satisfaction delivery systems. Some have suggested that there are successive stages in design that offer qualitatively improved levels of environmental performance. (See for instance Vermeulen and Weterings, 1996) Figure 5 in paragraph 3.4 depicts these stages. The time axis suggests that it takes longer to produce systems changes than product redesign, for example.

More recently, researchers have raised questions about this progression and the impact of the shift from products to services. In a comprehensive look at car sharing, Meijkamp concluded that 'eco-efficient services' could not produce the magnitude of impact reduction consistent with calls for factor 10-20 improvement. (Meijkamp, 2000) The effectiveness of leasing, a key strategy in the product to service transition, is questioned in research work by Inform, Inc. (Fishbein et al., 2000) The authors argue that leasing programs may not lead to consistent dematerialization through end-of-life recovery unless some 10 factors are considered in the design of the lease and its organizational context. These works point to the need to look more carefully at the specific nature of the satisfaction-delivery system.

The following discussion examines the scheme in Figure 5 and proposes an alternative structure.

The design of eco-efficient or of more sustainable processes and products has become a standard practice in many firms around the globe (Stages 1 & 2). The objectives of such eco-design is to find artefactual forms that are superior to the ones they substitute largely via three strategies:

- De-materialization
- De-toxification
- De-energization (or de-carbonization)

In this stage of redesign, one of the primary approaches is to examine the life cycle impacts of the artefact and seek changes that produce the desired results in the above list. Little or no consideration of the functions or purposes of the artefact is involved at this stage. In fact, one of the key aspects of using LCA's in design is to assure that any two designs that are to be analyzed and compared have the same functional equivalence. For example, different size bottles or delivery systems must be compared on the basis of a fixed quantity of contents.

The first two stages represent re-design modes for both processes and products. In this stage, the design maintains its basic character and performance modes. We may change the materials used to make a bottle or even a more complex artefact like a car. In thinking about complex artefacts like cars or electronic goods, however, it is not clear what constitutes product redesign. Is using an improved ignition/carburetor system for an internal combustion engine in a car a product redesign or does it fall into the next category of functional innovation?

Functional innovation (stage 3), in this scheme, means the substitution of a new artefact that performs the same function as the one it replaces. New is used in the sense that the artefact has a different character from the old and is based on a different operating concept. The boundary between these two categories (stage 3 and stage 2) is a bit fuzzy. As shown in Figure 5, this stage, functional innovation, is presumed to offer more potential for environmental benefit than the earlier ones. In this stage, one seeks alternative systems that provide the same outcome. Such innovations can range from simple notions like changing the size of a milk container to achieve material and transport efficiencies or replacing the type of engine in a car.

An improved internal combustion engine may be conceptually and operationally different from the one it replaces, but it continues to function in the same way. But the car, taken as a whole, is more or less the same as before, It is critical, then to look at the context in which an innovation shows up in practice in deciding what stage of innovation it represents. This distinction is important when one is concerned with the institutional arrangements in which design takes place and the structures in which the artefact is to be used (infrastructure). Functional innovations generally preserve the basic way the system is used and require little or no change in the infrastructure. Thus, the improved car described above needs little change in the supporting infrastructure. The user can adapt to using the improved vehicle transparently and does not even have to know that a change has occurred. On the other hand, repair mechanics will have to learn new skills and perhaps require new tools.

The fourth stage, system innovation, is one where both a new artefact and a new infrastructure replace the old. Continuing with cars for a moment, the replacement of gasoline-fueled, internal combustion engine powered vehicles with methanol- or hydrogen-fueled fuel cell powered vehicles would be a system innovation. Entirely new infrastructure would be required. The performance of the car might be different enough from the old to require that the user acquire new practices and skills. But again, the boundary between this stage and the previous one is a bit fuzzy. Where should one place the electrically assisted vehicle that Ford has announced? As far as the driver and the majority of the infrastructure are concerned, nothing has changed.

There is a fifth class of innovations that has not been explicitly included in this present classification scheme. These are innovations where the artefactual system remains more or less the same, and where innovative institutional arrangements lead to the benefits. Examples here are car-sharing, leasing instead of purchasing and owning, rental of work clothes, and so on. The highly cited, but relatively unsuccessful so far, carpet-leasing program of Interface Carpet falls into this category.

Recapping, then, we say that **process product redesign involve little or no change in the design concept or in the quality of the design as seen by the user and virtually no change in the infrastructure.** The new items can be used as transparently as the old without the requirement of new practices or learning. **Functional innovation involves changes in the design concept, but like the prior changes, the user sees little or no changes. Some change in the infrastructure is likely. System innovation involves changes in all categories. The design concept is new; the user will need to learn new practices, and new infrastructure will be necessary.**
We will add another category, institutional innovations, to represent the last type of innovations that involve only or primarily institutional or infrastructural change. What many call services fall into the institutional category since in the general case, services involve the same artefacts as those a consumer uses in self-satisfaction activities.

These categories are summarized in Figure 12**: the Sustainable Systems Triangle**. We have dropped the notion of stages, as we noted that any orderly progression from the top to the bottom in terms of sustainability performance has yet to be firmly established. Product and process redesign is lumped into a single category: device. The different categories are constituted by three factors of change: in the artefact, the institutional arrangement in which the artefact is used, and in the user's practices, respectively.

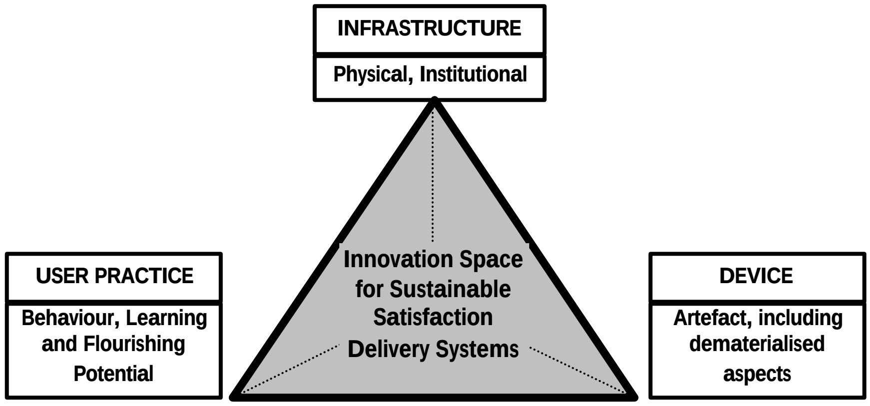

Figure 12: The Sustainable Systems Triangle (SST)
Explanation: When designing sustainable systems, the SST framework suggests designers to holistically look for the innovative potential of (1) the devices/ artefacts applied; (2) the physical and institutional context/ infrastructure; and (3) the potential of new user practices and user learning.

To see how the SST scheme works, let us look at a specific case and see how it fits, for example, let us examine a case being considered by a manufacturer of kitchen appliances in which the basic oven can be upgraded for fashion or functional reasons by the owner. This new development is being carried out in the 'service' department of the firm. This is consistent with the general notion of product-life-extension as a 'service' (Stahel, 2000) But if we look to see where it fits in the SST scheme, it would be in all three corners of the triangle. The device has technically been changed for upgradability. A new marketing and care infrastructure is needed. The user will have to learn some new practices. By categorizing it as services only, the design process may end up in the 'wrong' part of the firm, out of sight from the 'product' designers and the competence of the marketing department, that takes care of the contacts with clients and distribution channels. The other way around: by looking consciously at the oven redesign from a SST perspective, unexpected new options for a sustainable system design have been generated with an interesting eco-efficiency potential. As depicted in Figure 12 and 13, new designs should take into account the sustainable potential of not only technical redesign of the artefact, but also of other institutional arrangements and physical infrastructures, as well as the potential of new user practices.

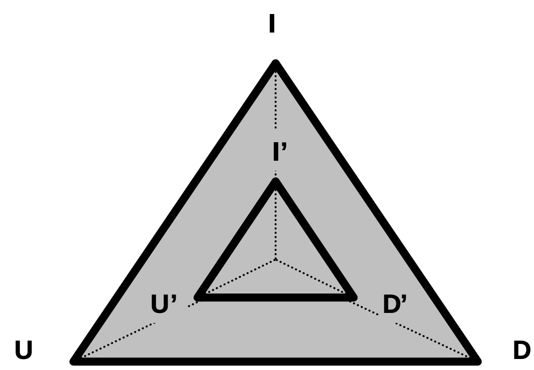

Figure 13 The Upgradable Oven in the SST Scheme
Explanation: To reach the envisaged sustainability improvement changes are considered in (1) the technical device;(2) the marketing and service infrastructure; and (3) the user behaviour (do-it-yourself-service for the new design). Because the envisaged changes are radical compared to the existing oven system D', I' and U' are depicted relatively far from their origins (the corners of the triangle).

This characterization of innovative categories and the above discussion suggest that the key to designing more sustainable satisfaction-delivery systems may be in looking with an integrative perspective into the innovative potential of device change, infrastructural factors change and user behaviour change at the same time.
In annex 9, describing the DES cases, the relative score of each ES within the SST scheme has been depicted. Also, from these cases it becomes clear that the real challenge in the design of sustainable satisfaction-delivery systems is to develop new systems in which changes in device, infrastructure and user behaviour work most effectively and efficiently together for the goal of eco-efficiency, or better sustainability.

Ad III. The humanistic side of eco-innovation

In the move towards services, something very central to sustainability may have become lost. Services, as opposed to products, produce relatively instant satisfaction and require little from the consumer other than sufficient funds to purchase the services. This mode of satisfaction has the distinct character of a commodity (Borgmann, 1984). There is no learning involved. Instead the opposite process occurs. Consumers gradually unlearn competent skills they might have once possessed relative to producing self-satisfaction, using tools (products) that they have previously purchased. The consequences of this unlearning or de-skilling process are loss of autonomy and increased dependence on the purveyors of the services. The experiential context of such other-satisfaction modes is narrow and probably fails to spill over into other domains of satisfaction, as do practices in more 'home-like' places. If this occurs, the consumer may (and does according to many surveys) feel unsatisfied and seek more consumption to fill the hole.

Looking positively, the humanistic domain offers a set of design criteria attached to sustainability that can potentially radically extend the idea of product/service systems. One possibility, for example, is to ask whether the technological offerings to be found in the market place of affluent communities satisfy the human striving for authenticity, that is the discovery of one's 'true' self. Or in less affluent areas of the world, the relevant question is whether these offerings satisfy more basic needs according to some Maslovian-like hierarchy. The recent SusHouse project at the Technical University of Delft suggests that it is possible to produce gains in the naturalistic dimension (dematerialization) simultaneously with positive results in the humanistic (Vergragt, 2000) This report described gains in the strength of relationships among families, an attribute closely related to flourishing.

New theories of design delve into the domain of behavior-steering attributes of artefactual systems that may be incorporated in the design. (Jelsma, 2000) In the self-satisfaction mode, consumers develop routines through which they produce satisfaction. These routines represent practical learning acquired through use. The designer, consciously or unconsciously, builds in such routines in the artefact. But the user may depart from the intended practical routine with unexpected and unpredicted outcomes. In the language of post-modernism these routines are mediated by 'scripts', a linguistic equivalent of the message the user gets from the object when it is being used. (Latour, 1992) Reflecting the asymmetry of the designer's intentions and users realization, Akrich and Latour refer to 'scripts" as the routines inscribed by the designers in the artefact and described by the users in actual practice (Akrich and Latour, 1992).

This theory of practice, which suggests that users create meaning through use, raises the possibility that designers can inscribe scripts with more than mere utilitarian ends. As Jelsma writes (Jelsma, 2000):

…In the context of a policy aiming at fostering sustainability, designs of artefacts must seek to mediate between the wants of users and the (represented) needs of nature, instead of just serving consumers. To develop such mediating designs, we need a new design paradigm (concepts, strategies, tools) bridging the gap between technical functionality, user needs and sustainable development….

7 THE FUTURE OF ES DESIGN

The results of the DES project (practical tools) and the reflection of Chapter 6 show an interesting sustainability potential when moving away from the mere ecodesign of artefacts. Relevant notions and tools have been developed, that need further “reflectice practice” and refinement from experiments. It has become clear that, next to entrepreneurs and responsible business leaders, industrial designers can significantly contribute to the “sustainability journey”.

The DfS program of TU Delft

Based upon it’s experiences with the design of Eco-efficient Services, or preferably, the design of Sustainable Systems, the DfS program of TU Delft will focus on:

- The integration of the Sustainable Systems Triangle (SST, see Chapter 6), as building block for the Exploration and Policy Formulation phases, into the ES methodology, as well as the analysis of it’s consequences for the subsequent phases of the ES development;
- Refining and expanding the ES-methodology and tools, regarding among others ES-benchmarking, an ES-LiDS wheel, generation of green options, EVR method, Purchase and Rules of Thumb for ES;
- Applying the Sustainable Systems Triangle as a tool for analyzing emerging new PSS with respect to their sustainability potential;
- The development of the website ECOSM, in order to build flexibility and new insights in the DES toolbox. This website should support a rapid further development and dissemination of the DES methodology and serve as a discussion platform;
- Continuation of “ES Experimentation” within the DES project, based on new Kathalys cases, SusHouse, new ES projects with Shell, Motorola and other industries, European projects within the ‘PREPARE – EUREKA’ network as well as via sustainable tourism cases.

Research recommendations

The following recommendations came out of the project:

- Much more attention of policy makers, companies and educational institutes for the ES redesign of potentially unsustainable, existing and emerging, services, in particular energy intensive ICT (see also Huiberts, 2000);
- Further experiments with ES methodology and ES promotion via amongst others the networks and programs of PREPARE-EUREKA, the EU and UNEP.

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A. Cases

Ahrend Office Furniture

The office furniture firm Ahrend wanted to investigate the possibility to expand their product portfolio with a service. This idea was partly the effect of demand from the market and partly a spin off, from the Kathalys project Sustainable Office of the Future. In this project Ahrend, KPN, Xerox, IBM, TNO Industry, and the Delft University of Technology have developed scenarios for an eco-efficient workspace. The original project aimed at the realisation of an eco-efficiency leap in the office environment by using new intelligent technologies parallel with new concepts for the workspace. By designing customised telecommunication infrastructure, better adapting equipment to expected information needs and document flows, using mobile furniture and presentation concepts and with all this use energy intelligent equipment and installations, substantial reductions in space occupation, energy use, paper, furniture and equipment can be reached.
Research has been conducted among future users in offices, expected new technologies have been mapped and several 'efficient workspace' concepts have been developed.
Ahrend, traditionally a sales organisation of office interiors, emerged from this exploring stage with an idea for a new Eco-efficient service. The development of this new ES, which could also imply starting a new business or business unit, should be conducted in various pilot-projects with clients of Ahrend.
A preliminary calculation of the possible environmental gain, gives a saving of 25% in use of space and energy and 30% saving on the purchase of office furniture (which saves materials and costs).
The possibilities of the new service are currently tested in various development pilots. These pilots serve to investigate the feasibility of the service as a new business for Ahrend, while at the same time a concept development process is evaluated. (Reijnhoudt, 2000)

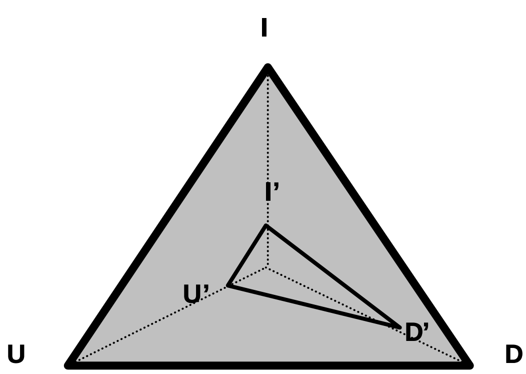

Figure 14: The ahrend Case in the SST Scheme
Explanation: Only small changes in the device are needed, but big changes in marketing and business infrastructure as well as in user behaviour.

Car Sharing

With Car sharing, subscribers can have a car at their disposal at any desired time, which implies they do not need to own a car anymore. In other words, Car sharing is a form of car renting with minimised discomfort for the customer.
This means in practice that the rental company is localised near the customer or delivers the car at the customer's house, that there is an optimal availability of very well maintained and modern cars and that attractive financing is possible.
Car Sharing has started as an experiment in 1995 in the Netherlands, initiated by a few young entrepreneurs and has at this moment 25000 participants in 100 cities with 500 rental points. The idea of car sharing is a few decades old, but recent developments in information and communication technologies make a car sharing system economically feasible. Although the Car Sharing business has been set up because of commercial opportunities, the environmental potential of replacing owned cars by rented ones was recognised in the early stages. The Delft University of Technology has been involved in the development since the start of the experiment with continuous evaluation of the behaviour and attitudes of the participants. Recently a dissertation written by Meijkamp (2000) about this subject has been published, in which the environmental benefits have been examined. He found that a kilometre in a shared car compared with a kilometre in an average car has 14% less environmental impact. This small improvement follows from efficiency gain of shared cars. Much more environmental benefit follows from the behavioural changes caused by the Car Sharing system. People who formerly owned a car, but switched to a shared car use this car 65% less, while their overall mobility increases with 13%. This means that they use other modes of transportation, like bicycle, train and bus. Compared with the average Dutch household the environmental gain is 40%. And this does not even cover the decrease in necessary parking space, a big problem in cities. Meijkamp speculated that with an increased number of subscribers the environmental gain could be much higher. An important barrier is the emotional value many people see in owning a car, no matter how many benefits Car Sharing has.

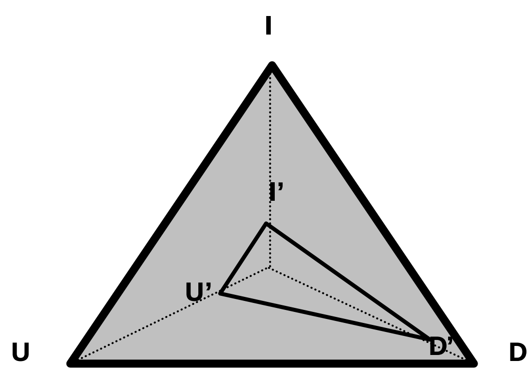

Figure 15: Car Sharing case in the SST Scheme
Explanation: No or very small changes in the car design, big changes in infrastructure and user behaviour.

Upgrading of an Atag oven

Inspired by the EET-project of Atag, which is aimed at the development of an energy efficient and intelligent kitchen for the future, the service department of Atag has started to look for possibilities for the development of Eco-efficient Services. A wide array of ES options has been generated for Atag, from which 'upgrading of an oven' has been chosen as the most suitable. Adapting the product to changing consumer needs by changing the appearance of the oven (front, buttons), adding or deleting functions and thorough maintenance can double the economic life span of the oven. Preferably the upgrading is done by the consumer himself, for example with the help of parts

delivered by mail. This concept has interesting opportunities for Atag to deliver added value and has the possibility for an environmental improvement of 5 to 16%, mainly by product life extension.
(Brügemann, 1999)
An important characteristic of this case is that the current business situation formed the starting point and the limitations of the innovation project. This reduced the possibility for system innovation considerable, but accelerated the total time needed for the project.

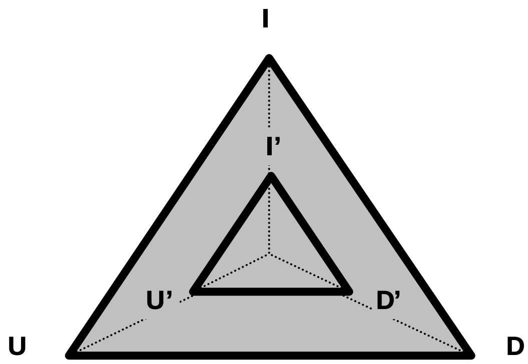

Figure 16: Upgradable Oven case in the SST scheme (see for explanation paragraph 6.1)

Outsourcing of clothing and clothing care

The so-called SusHouse-project is conducted by six European research institutions, among which the Delft University of Technology. In this project, research has been done, based on the "backcasting-scenario-stakeholders" approach, to answer the question whether and how the eco-efficiency of domestic functions could be improved by a factor 20 in 50 years. One of the functions on which the research focussed was 'clothing and clothing care'. From the backcasting workshops about clothing, several "design oriented scenarios" (DOS) have emerged. An example of such a scenario is "outsourcing of clothing and clothing care". In this future scenario professional service providers are the owners and caretakers of clothing. Households can subscribe to this organisation, which enable them to have clean clothes at their disposal on a rental basis. It is also possible to subscribe to a personal lease-service, which provides the client with a wardrobe over a certain period of time, based on individual preferences.
In all these cases the service provider organises the cleaning in professional launderettes, supported by so-called "dirt indicators", which indicate when clothing should be washed and how. Underwear is not part of this system, but is made of biological degradable disposable materials.
For every scenario in the SusHouse project an environmental analysis was conducted, based on an adapted LCA (scenario) method. The analysis of the "outsourcing of clothing" scenario reveals that this system could lead to a reduction of 95% in materials and waste, to significant savings in energy, detergents, washing machines, and water. At the same time however, it could lead to an increase of travel kilometres and waste from disposable underwear.
This outsourcing concept is currently developed further in a new commercial business concept by one of the participating companies of the project.
(Vergragt, 2000)

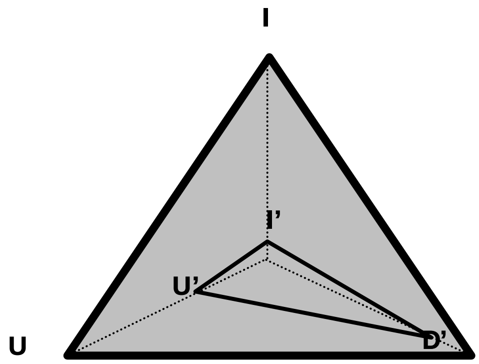

Figure 17: Clothing and clothing care in the SST scheme
Explanation: Some changes in the device, big changes in user behaviour and infrastructure.

Mobility plan Texel

In 1997 the Dutch island of Texel, initiated by the then mayor, conceived the plan to redesign its mobility system for tourists. Caused by the yearly growth in car mobility, congestion problems exist on peak days, waiting times increase for the ferry boat and a continuous adaptation of the infrastructure (roads and parking space) is necessary. On top of that, the image of the island of 'Rest, Space and Nature', is negatively influenced by this growth.
The size of the island makes it unfeasible to completely ban the car. That is why the Workgroup Sustainable Tourism Texel, in which all stakeholder groups are represented, has ordered studies and made a plan for attractive public transport on Texel.
Initially, this plan focussed on the realisation of an Eco-efficient Service with free public bus transport, in connection with the already successful telecom-taxi service on the island. Another part of the plan was peak shaving: shifting arrival and departure hours of guests from the traditional Friday to other days by giving discounts on ferry tickets. The consultancy DTV has developed, in collaboration with bus company Connexxion, several alternatives for the existing bus system. The so-called STAR-model was preferred in terms of quality and costs. This system should allow twice as much tourists to take the very cheap bus and a modest environmental gain could be reached in the short term. A temporary subsidy to set up, and if needed, adapt this new system was promised by the Province of North Holland.
Additional research of the Delft University of Technology proved that the environmental benefits as far as tourist transport is concerned would be significantly higher when there would also be more substitution of the car with the bicycle. An LCA scenario calculation indicated a possible saving of 30%, based on a flexible and partly mobile system of bicycle issue points.
By now the subproject peak shaving, a collaboration between Teso boat service, the society of hotel owners and the Tourist Information service, has been realised and is currently being expanded.
Due to heavy resistance of the Society of Bicycle Rental Companies of Texel, the new mobility service has been redesigned. They feared false competition of the – almost free – bus and felt that the carrying out of a sustainable bicycle plan should prevail above an improved bus service. The society was supported in this view by lobby organisation Bovag, the Bicycle Federation and the powerful local political party Texel's Belang.
The redesigned plan gives a stronger priority to the substitution of cars by innovative bicycle concepts (partly with electrical power support), car sharing and chain mobility, that is the possibility for tourists to easy move from one transport mobility (for instance the bus) to another (bicycle, cab, etc.). Within the new system, a new coordinating organization has been envisaged, Texel's own mobility service (TEMO). The new plan will be implemented from September 2002, having gained the support from the Province of North Holland and the Minister of Transport as national demonstration project for chain mobility.

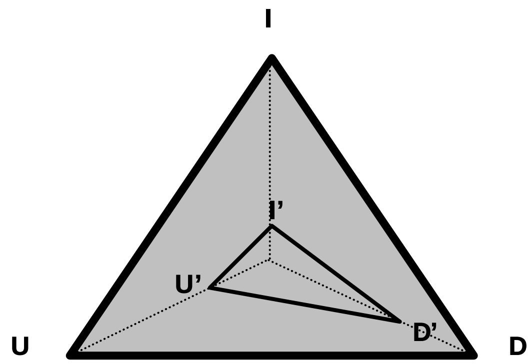

Figure 18: Mobility Plan Texel in the SST scheme.
Explanation: Relatively radical changes are foreseen in all aspects; the devices to be used (new bicycle concepts, technically adapted busses and cars), the infrastructure (physical: possibility for chain mobility; institutional: new service organisation) and in user practices (chain mobility, use of human power, information use).

Mobility concept for individual transport on short distances (MITKA)

This project has been carried out by four companies: TNO (research institute), NIKE (sporting goods), Gazelle (bicycles) and Stork (machinery). These companies had different roles in the process: developer, future client and producers. Goal of the project was to find an alternative transportation system for home to work traffic on distances shorter than 20 kilometres. The majority of travelled distances in the Netherlands are shorter than 20 kilometres, while on these short distances the emission of harmful substances by cars is worst. Besides, increasing car traffic is leading towards serious parking and accessibility problems for companies.
To deal with this problem, the project team has developed two things: a new means of transportation that combines the advantages of cars and bicycles, and a package of services to increase the attractiveness by customisation. The functionality of the Product Service System was made to exceed the functionality of the car, so people would leave their cars at home. This is what makes it an Eco-efficient service. The expected environmental gain in replaced car kilometres is about 3 %.
The project has now come to the end of the first development stage and is ready to be produced, tested, improved and launched.
The collaboration between the participants passed without any problems. This was possible due to a very thorough project plan and a clear division of tasks.
(Flipsen, 2000)

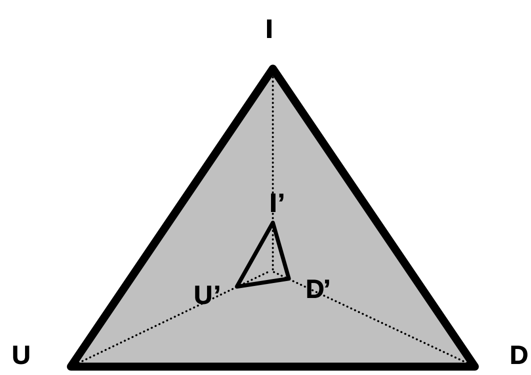

Figure 19: The MITKA case in the SST scheme
Explanation: radical changes are envisaged in the device (world premiere of a car/ bicycle integration), the infrastructure (new MITKA service from Nike required) and the user (cycling instead of car driving)

B. Overview of ES-specific barriers

New barriers for the development of Eco-efficient Services

BUSINESS VISION DEVELOPMENT

Barriers	Possible solutions	Tools
To innovate on a system level, people and companies need to have al long term vision.	Formulate strategy and policy for the short, medium and long term	• Strategy and policy tools • Scenario writing • Backcasting • Roadmapping
System level innovation involves high risks because of high level of uncertainty.	Spread risks by joining forces	
For system innovations business coalitions or new businesses are needed.		• Network management • General process management

POLICY FORMULATION

Barriers	Possible solutions	Tools
Goals and strategies need to be formulated in such a way that an eco-efficient combination of products and services is a possible outcome.	View from a higher level of abstraction. What kind of functionality or added value do you want to deliver?	• ViP • Roadmapping
An environmental goal should be formulated.	First the current situation needs to be analysed on environmental impact. Then goals for the new ES can be formulated.	• Current ecodesign tools • LCA scenarios • Adapted MET-matrix
When a network of companies is involved a joint goal needs to be formulated.	Project management, Stakeholder analysis	• Project management tools (planning, flowcharts, budget etc)
A network of companies needs to be managed.	Central management	• Network management

IDEA FINDING

Barriers	Possible solutions	Tools
Customer need should be translated in functions, not in products.	Function based market research	• Quality Function Deployment (QFD)
Products as well as services should be regarded as possible part of the solution.	Environmental gain as a starting point	• Blueprinting • Adapted MET-matrix • Adapted LiDS-wheel • Green options generation • Benchmarking • Ecocosts/value approach
The development of different elements of the solutions should be planned in advance.	Project management	• Project management tools

STRICT DEVELOPMENT (DESIGN)

Barriers	Possible solutions	Tools
The development is split up in several parallel sub processes.	Outsourcing or purchasing	• Eco-purchase • Blueprinting
An indication is needed of the environmental gain of designed concepts	Quick and Dirty environmental analysis	• LCA scenarios • EVR (Ecocosts Value Ratio)
The final total solutions should result in environmental gain.	Special ES strategies and rules of thumb	• Adapted LiDS

REALISATION

Barriers	Possible solutions	Tools
All components should be completely developed and tested before the final ES can be marketed.	Thorough planning and management	
The solution will often be relatively new for the customer.	Good communication	• Green communication
The final version needs to be evaluated on market success and environmental impact.	To assess the environmental impact of services, they need to be described as a collection of products.	• EVR • LCA scenarios

C. The META-matrix

For a fast evaluation of the environmental impact of physical products exists the MET-matrix (Brezet et al, 1997). See Figure C1. MET stands for Materials, Energy and Toxic substances. On the vertical axis of the matrix, the phases of the Product Life Cycle are reflected. The filling in of the matrix can be done qualitatively as well as quantitatively. The filled in matrix is intended to give insight in environmental problem areas.

MET-matrix		**Materials**	**Energy**	**Toxic substances**
		Input/ output	Input/ output	Output
Production and delivery of materials and components				
Production				
Distribution				
Use	Operational			
	Maintenance			
End of Life	Collecting			
	Disposal			

Figure C1: the original MET matrix for products (Brezet et al, 1997)

This tool was adapted to make it suitable for the analysis and benchmarking of services. Because the environmental impact of services wholly consists of the environmental impact of the products and support material that are used with this service, it is not necessary to adapt the horizontal axis (M, E and T). There will be added one column however, which reflects the Added Value to approach the EVR model (Vogtländer, 1999), hence the META matrix. See figure C2.
More has been changed in the vertical axis. De lifecycle of a product is very different than the life cycle of a service. With a service, production, use and disposal happen virtually in the same instant. In addition, the limitations of what belongs to the service system and what not are not always as clear as with products. These system boundaries need to be determined at the start of the analysis and will be specific for every product service system.
One thing that is the same for every service is the fact that the environmental impact is determined by products and materials that are needed to deliver the service. That is why the vertical axis is diverted in categories of products and support materials. See figure C2. Of course one could have summarised this in one line: products that are used with the service. The diversion in categories is, like the examples mentioned in the matrix, meant to support the designer not to overlook anything. If desired, a separate traditional life cycle MET matrix can be made for every support product.
An important difference with the analysis of physical products is the adding of personnel and infrastructure to the analysis. Also the use of certain capital goods like computers are part of the analysis, while they are often regarded as negligible when physical products are analysed. With services these ‘second order’ products and infrastrucures are of concern, because this type of products often determines a great part of the product share in product service combinations.
While personnel alone hardly causes any environmental impact, this category has been added because personnel does often determine a significant part of the added value.
(Bijma, 1999)

META-matrix	Examples	Materials	Energy	Toxic substances	Added value
		Input/output	Input/output	Output	
Transportation	Truck Plane Ship Train				
Infrastructure	Road net Telephone net Water net GSM net				
Buildings	Offices Climate controlled warehouse Shop				
Personnel	Mechanic Office clerk Salesman Consultant				
Tools and support products	Laptop Electric drill Telephone Camera				
Consumption goods	Paper Water Detergents Chemicals				
Main service products	Washing machine Copy machine Locker Gambling machines				

Figure C2: the META-matrix for services (Bijma, 1999)

In figure C3, an example can be found of a filled in META matrix.

META-matrix	Medium	Materials	Energy	Toxic substances	Added Value
		Input/output	Input/output	Output	Costs from user perspective
Transportation	Traditional mail	car's train bicycle (as well of the user as the letter)	20,7 kJ (use) Production energy	Production emissions	(included in stamp)
Infrastructure	Telephone	Cables Exchange points	1,3 kJ (use) Production energy	Production emissions	27,20/ 200 + 0,10 = ƒ 0,24 8 min * 0,20 = ƒ 1,60
	Fax	Cables Exchange points	0,3 kJ (use) Production energy	Production emissions	27,20/ 140 = ƒ 0,19
	Email	Cables Exchange points	1,1 kJ (use) Production energy	Production emissions	27,20/ 100 = ƒ 0,27
	Traditional mail	Road net	Production energy	Production emissions	(included in stamp)
Buildings	Traditional mail	Mail collection building	Production energy	Production emissions	(included in stamp)
Personnel	Traditional mail	Postman			(included in stamp)
Tools and support products	Telephone	2 telephones[4]	2 x 0,4 kJ (use) Production energy	Production emissions	ƒ 250 / 12000 = ƒ 0,02
	Fax	2 faxmachines[3] computer[1] printer[2]	2 x 156 kJ (use) 80 kJ (use) 32kJ (use) Production energy	Production emissions	2 x ƒ 500 * (2/9870) = ƒ 0,20 ƒ 3000 * (20/ 169200) = ƒ 0,35 ƒ 1000 *(1/ 35250) = ƒ 0,03
	Email	2 computers[1]	107,7 kJ (use) Production energy	Production emissions	2 x ƒ 3000 * (15/ 169200) = ƒ 0,53
	Traditional mail	computer[1] printer[2] mailbox	80 kJ (use) 32kJ (use) Production energy	Production emissions	ƒ 3000 * (20/ 169200) = ƒ 0,35 ƒ 1000 * (1/ 35250) = ƒ 0,03
Consumables	Fax	A4 paper Ink	36 kJ (production) production energy	 toxic	ƒ 0,16 ƒ 80 * (1/300) = ƒ 0,27
	Traditional mail	A4 paper envelop stamp ink	36 kJ (production) 32 kJ (production) production energy production energy	production emissions toxic	ƒ 0,04 ƒ 0,20 ƒ 0,80 ƒ 0,02

Figure C3: Example of a filled in META matrix: comparison of four media for sending messages (Klok et al, 1999; Bijma, 1999)

D. Blueprinting

To systematically describe a service, the blueprint technique has been developed (Zeithaml, 1996). With this technique, the activities that constitute the service are chronologically ordered. The interaction with the customer is a central theme.
To make a blueprint Zeithaml gives eight steps that need to be undertaken, which will be discussed below.

1. Identify the Service Process to be blueprinted.

Determine the system boundaries of the service to be analysed. Formulate the level of detail that should be reached. When possible identify expected bottlenecks that should be analysed in more detail, for example with a separate blueprint.

2. Map the Service Process form the customer's point of view.

Describe the customer. Make a different blueprint for every category of customers. Map out the actions and choices of the customer regarding the perception, consumption and evaluation of the service. Give special attention to what is perceived as the start and the end of the service.

3. Draw the line of interaction

Identify all customer contact and the types of interaction that occurs.

4. Draw the line of visibility

Point out the aspects of the service that are visible to the customer and those that are not.

5. Map Contact Employee Actions, both onstage and backstage.

The activities of the company that involve customer contact are identified, both visible (on stage) and invisible (backstage) activities. It is important for the company to recognise the difference the client perceives between these two activities.

6. Draw the line of Internal interaction

Describe what happens backstage, invisible to the customer.

7. Map Internal Support Activities.

The next step is to fill in the activities that support the interaction with the customer (Internal Support) without having direct contact. This reveals the influence of these support activities on the total process.

8. Add Evidence of Service at each customer action step.

At each process part, the physical evidence that the customer receives or sees is identified. Examples of physical evidence are certificates, contracts, etc.

Reijnhoudt (2000) ads an extra step to these eight steps, which is especially designed for product oriented companies trying to go into the service business.

9. Add Non-Phycical Evidence of service at each customer action step.

At each process part, Non-physicall evidence that is perceived by the client is identified. Examples of non-physical evidence are the friendliness of personnel and waiting times.

To demonstrate the use of a blueprint, a filled in example is shown in figure D1. The service reflected is a taxi service.

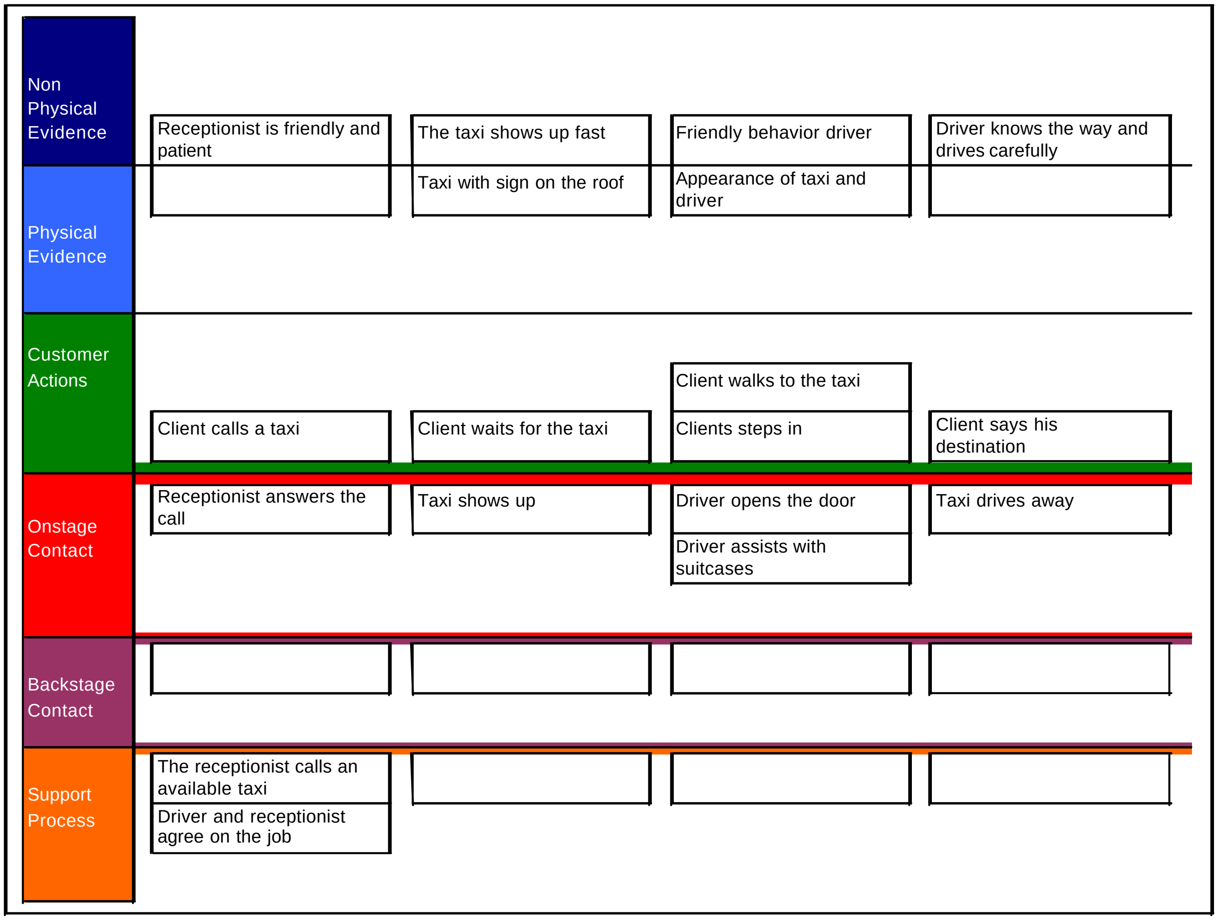

Figure D1: blueprint of a taxi service. (Reijnhoudt, 2000)

E. The VIP-approach (Vision in Product development)

Note: This description is based upon the article “ViP – Visie in Productontwikkeling” from Paul Hekkert and Matthijs van Dijk. Faculty of Industrial Design Engineering. TU Delft. Febr. 2000.

The ViP approach aims at the development of an innovation vision on future products for a company or design consultant.
The framework of the approach includes the following elements:

- the designer: is responsible for his/her vision on the world and has, in the design-decision making process, sufficient space for free, personal and conscious choices;
- the product: according to the designer the product represents an important value in the world. It is the result of a personal and free design process, lead by opportunities (in stead of restrictions) and therefore, it is original. It can also be new and unusual, but this is not a requirement;
- the context: a product, a user and their relation are not only part of a context, but also are being created by the context. The product-user relationship can be considered as an entity that should fit into the context, like an organism has to adapt to the ecosystem where it’s part of;
- the company: the ViP approach expects from the company to give the designer the necesarry design freedom. This means that it will have to refrain from pushing the designer in certain directions, based upon prejudices on”how things are or should be”. On the contrary, from the company an active and stimulating role in the design process is being expected;
- the user: the user is the object of the design but not the co-designer in the ViP approach. The reason for this is the thinking and feeling of users based upon their past experiences and their present mental framework, that is aiming at problem solving in stead of thinking in new opportunities;
- the interaction: the product-user relationship is to a large extent being determined by the context. Therefore, it is important for the designer to first build an image of this context and the interaction process, before designing the actual product.

Based upon these elements, the ViP approach follows the next 6 phases in the design process:

1. Destructuring

In this phase it is important that the designer gets rid of all knowledge and insights, which have created the existing product-user relationship. Fixation on existing knowledge will not lead to original solutions. All implicit assumptions should be reconsidered. For the designer, not only the product is the subject of study, but also the user needs and context variables that were important in the product creation process.

2. Creating a new context

In order to be able to determine which circumstances and factors are influencing the new product-user interaction, it is necessary for the designer to build a new context. For this, two strategies can be followed: (1) reformulation of the present context or (2) description of the future context. In this phase, information retrieval is crucial, particulary focussed on the aspects that emerged during the destruturing phase. As search fields also completely other domains should be taken into account, to enlarge the chances on new insights on the design problem.

3. Formulating the interaction vision

In this phase the designer defines the interaction vision, based upon the new context. An interaction vision is a presentation or understanding of the interaction between a (future) product and a (future) user, as envisaged within the new context to create a new balance.
An appropriate interaction vision (1) has a clear and consistent relation with the context description; (2) is being formulated at a sufficient operational level for the further design process; and (3) gives certain original new insights into the existing product-user relation. Particularly, the interaction vision might become interesting, if it involves new characteristics that were not involved in the existing interaction.

4. From interaction vision to product vision

Based upon the interaction vision, now it's possible to define the qualitative characteristics of the product to be designed: the product vision. They can relate to the product's meaning, function, value, style etc.. An appropriate product vision fulfills the following demands: (1) a clear and consistent relation with the interaction vision; (2) is suffiently operationalized; and (3) is to a certain extent original, compared with existing products.

5. Turning the product vision into a product concept

Now, the product vision and the underlying interaction vision serve as a programme of requirements for the product conceptualization. This step is principally not different from the "normal" product development process as for instance described by Roozenburg and Eekels (1991).

6. From concept to design

Eventually a new product or product-systeem emerges from the design process, again using the standardl tools and methods as described in Roozenburg and Eekels. However, in many ViP based projects the final result will be the product concept as generated in phase 5.

Literature

Roozenburg, N.F.M. & Eekels J. (1991). Produktontwerpen, struktuur en methoden. Utrecht. Lemma.