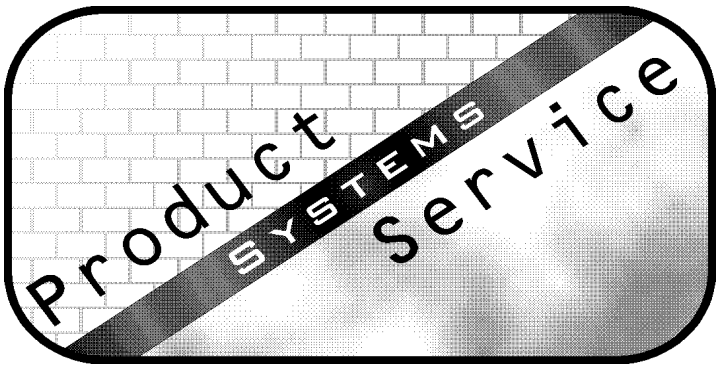
Product Service systems,

Ecological and Economic Basics



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This paper is on *Product Service systems* (or product service combinations), commercial deals containing both a material product and an intangible service. The writers propose a method to analyse the economic and ecological qualities of these systems. They believe an understanding of product service systems is a next step on the way to *econology*: the junction of ecology road and economy lane. This text gives basic observations and definitions, offers an outline of a new assessment method and ten case descriptions. This paper has been written to stimulate discussion on this promising subject. It has been commissioned by the Dutch ministries of Environment (VROM) and Economic Affairs (EZ).

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Summary

In the Dutch Policy Document on Environment and Economy, Product Service systems are recognised to offer favourable prospects for sustainable economic growth in the medium and long term. The policy document describes a phased policy plan to evaluate the potential of product-service systems with respect to environmental policy. The project reported here is the first step in this plan.

The project explores the subject 'products and services' in relation to sustainability, economy and environment. The project partners are PI Management Consultancy[1] (Pi!MC) in the Hague, STORRM C.S. Designers and Advisors in Den Bosch, and PRé Consultants in Amersfoort. Pi!MC was the project leader. First, the project focused on developing a solid theoretical framework. Next, new analysis methods were developed and case studies were described and studied. The project was externally oriented, including discussions with experts of industry, science and policy. The project is finalised February 1999 by means of a presentation of the results to the project steering committee.

A Product Service system (PS system, or product service combination) is a marketable set of products and services, jointly capable of fulfilling a client's need. Understanding PS systems is interesting for companies as well as governments. PS system knowledge enables governments to formulate a next step in policy concerning sustainable production and consumption patterns. PS system knowledge enables companies to find strategic options for business growth, renewal, innovation and diversification. PS systems knowledge is especially inspiring for those companies who regard sustainability as a co-pilot for management strategies.

PS systems can prove beneficial to the environment in combination to creating (new) business. Key-factors of success are similar in many cases, e.g.:
- *Creating value for clients, by adding quality and comfort,*
- *Customising offers or the delivery of the offer to clients,*
- *Creating new functions or making smart or unique combinations of functions,*
- *Decreasing the threshold of a large initial or total investment sum by sharing, leasing, and hiring,*
- *Decreasing environmental load. Often this will bring additional and perceived Eco-benefits,*
- *Increase the quality of the contacts with clients.*

Moreover, the study shows a potential to unlink environmental pressure from economical growth.

The project Product Service Systems has resulted in ten case descriptions. Three of these have been worked out quantitatively in terms of economic and ecological characteristics. For these descriptions a new analysing method has been used. Each case is characterised by four axes: an ecological axis, an economic one, an identity/strategy axis and a client acceptance axis. These axes are described in the report. For the ecological and economical axis quantitative methods are proposed as well.

To get an appealing representation of two core parameters, the economy and ecology axes have been combined. This has resulted in the ratio economic added value *(of companies on the network)* per unit environmental load, *which can be plotted graphically as what has come to be called the* E2 vector.

[1] All activities and advisors of Pi!MC are since September 1999 part of PricewaterhouseCoopers N.V. Subsidy- and Technology Advisors

The E2 vector enables benchmarking between a company's departments, between companies, between economic sectors and between different product service mixes.

Apart from case descriptions, the project has resulted in definitions, a database with examples, and policy recommendations for governments and companies. One of the recommendations is to discuss the PS theory in multidisciplinary sessions and to develop practice with PS systems.

Samenvatting

In de Nota Milieu en Economie worden product dienst combinaties genoemd als een kansrijk perspectief voor een duurzame toekomst. De nota beschrijft een stapsgewijze aanpak om hun potentie in het milieubeleid vast te stellen. Dit rapport schetst de resultaten van het project dat als eerste stap ter realisering van dit perspectief in opdracht van de Ministeries van VROM en EZ is uitgevoerd.

Het project is een breedte-verkenning van het onderwerp 'producten en diensten' in relatie tot duurzaamheid, economie, ecologie. Het is uitgevoerd door PI Management Consultancy[2] te Den Haag, STORRM C.S. Adviseurs & Ontwerpers te Den Bosch, en PRé Consultants te Amersfoort. Projectleiding was in handen van PI. In het project is allereerst gewerkt aan de theoretische kaders. Vervolgens zijn er nieuwe methodieken ontwikkeld en praktijkcases beschreven en bestudeerd. Hierbij is een open strategie gevolgd, waarbij een groot aantal deskundigen is gesproken uit het bedrijfsleven, de wetenschappelijke wereld en het beleid. Het project is in februari 1999 afgesloten middels een presentatie van de projectresultaten aan de begeleidingscommissie.

Een Product-Dienstsysteem (PD-systeem, of product-dienstcombinatie) is een verkoopbare verzameling producten en diensten, die gezamenlijk een functie vervult bij een klant. Inzicht in PD-systemen is van belang voor overheid en bedrijfsleven. De overheid kan kennis van product-dienstsystemen aanwenden voor een nieuwe stap in het beleid rond duurzame productie en consumptie.
Kennis van PD systemen biedt bedrijven mogelijkheid om nieuwe wegen te bewandelen bij het zoeken naar nieuwe strategieën voor groei, vernieuwing, en diversificatie. Ze is met name inspirerend voor bedrijven die duurzaamheid zien als centraal onderdeel van de management strategie of als grote nieuwe marktkans.

PD systemen biedt bedrijven een 'win-win' kans voor milieu en economie. Sleutelfactoren voor succes zijn veelal hetzelfde:
- *het creëren van waarde voor klanten (kwaliteit en comfort),*
- *customising aanbiedingen aan de wensen van klanten,*
- *het creëren van nieuwe functionaliteit of het leveren van unieke combinaties van functies,*
- *verlagen van de investeringsdrempel door sharing, leasing of verhuur,*
- *verlaging van de milieubelasting. Vaak kan hierdoor ook een hogere (eco)-prijs worden gerekend,*
- *verbeteren van de contacten met de klant.*

Het project laat tevens zien dat ze kunnen bijdragen aan het ontkoppelen van milieudruk en economische groei op macroniveau.

Het project Product-Dienstsystemen heeft geresulteerd in tien voorbeeldbeschrijvingen waarvan er drie cijfermatig op economische en ecologische kenmerken zijn gekarakteriseerd. Voor deze beschrijvingen is gebruik gemaakt van een nieuw ontwikkelde analysewijze op vier assen, te weten een ecologische as, een economische as, een bedrijfsidentiteits/strategie-as en een afnemersacceptatie-as. Elk van deze assen wordt beschreven. Voor de assen ecologie en economie worden er tevens methoden aangereikt voor kwantificatie.

De economie- en ecologie-as zijn samengebracht. Dit maakt een eenvoudige grafische weergave mogelijk van het kengetal toegevoegde waarde *(van bedrijven in*

[2] Sinds 1 september 1998 zijn alle activiteiten en adviseurs onderdeel geworden van PricewaterhouseCoopers N.V. Subsidie- en Technologie-adviseurs.

het netwerk) per milieubelasting. *Deze grafische weergave heeft de naam* E2-vector *gekregen. De E2-vector maakt benchmarking binnen een bedrijf tussen bedrijfsonderdelen, tussen bedrijven onderling, tussen sectoren en tussen functievervullingen inzichtelijk.*

Naast de voorbeeldbeschrijvingen heeft het project werkdefinities opgeleverd, een database met voorbeelden uit de praktijk, en aanbevelingen voor overheid en bedrijfsleven. Tot de belangrijkste aanbevelingen hoort de toetsing van het gedachtegoed in multidisciplinaire bijeenkomsten en het verder opbouwen van ervaring.

Contents

1. Introduction

1.1. Why has this document been written

Western policy aims at sustainable economic development. Long-term economic growth in combination with a reduced pressure on the environment asks for changes in our production and consumption systems and for commitment of all actors in society.
Key question is how environmental impacts can best be disconnected from economic activities. In the recent decade already many successful approaches have been followed. Examples of key concepts that are successful, are: 'cleaner production processes by new technologies', improved products by 'Ecodesign methods', 'improved technologies for waste processing' and the introduction of environmental (product) lifecycle management.

Many cost-effective environmental measures have now been taken. That creates the risk that the reduced environmental load per unit product will fall behind the growth in consumption, with the danger that pollution will start to rise, even in those sectors where reductions have been achieved in recent years. [3]

The next step in the process of sustainable development has to include new and powerful concepts. The accelerated transformation of production systems and consumption behaviour towards services and product-service combinations is recognised as a potentially powerful concept. Why?

- It is expected that services can be produced and consumed against low environmental burden. Development of services is expected to contribute to more effective use of resources.
- The combination of products and services can exceed the traditional functionality of products, in terms of quality and cost performance.
- The introduction of services can create new jobs near to home or even at home.
- New 'environmentally sound' service opportunities arise as result of the rapid progress of information and communication technology (e.g. Internet).

Transforming products into services and the combination of products and services are no new concepts in itself. Services are added in many cases to increase customer satisfaction. This will increase the overall value of the product that was sold. In general, markets steadily move towards production and consumption of more luxurious goods and services and this paves the way for new services.

What *is* new, is recognition that the service-based strategy could be a powerful concept towards sustainability. Basic idea is that a company's commercial value creation goes beyond the spreading of material goods. It's about function fulfilment of a business' clients. Or more beautiful, as Prof. Manzini has put it, it's about doing sustainable business, which means doing business enabling clients to live better, consuming less[4].

Experiments with added services reveal this potential.
Leasing carpets (by Interface, U.S.), sharing cars (in Switzerland, Germany and The Netherlands and other European countries) and furniture maintenance subscriptions (by Wilkhahn, Germany) seem exciting examples from an environmental point of view.

[3] Dutch Policy Document on Environment and Economy, 1997
[4] Prof. Ezio. Manzini (Politecnico Milano) at O2 Challenge in Rotterdam 1998.

This report will set footsteps into this New World of services and sustainability:
– by describing a number of exciting business cases,
– by describing new methods of analysis,
– and by trying to analyse of the real environmental benefits of selected cases in relation to their potential contribution to economic growth.

1.2. Dutch policy background

In the Dutch Policy Document on Environment and Economy, Product Services systems are recognised to offer favourable prospects for sustainable economic growth in the medium and long term. The document describes a phased policy plan to evaluate the potential of Product Service systems with respect to environmental policy. If the outcome is positive, this may be followed up by specific incentives:
- Phase 1: making an inventory, examining the possibilities and impossibilities.
- Phase 2: setting up pilot projects on the basis of the above.
- Phase 3: if the results are positive, developing a systematic approach directed towards the realisation of new Product Service systems.

The project reported in here is part of Phase 1.

1.3. Scope

Goal of the project

Objective of the project was to assess the economic and environmental relevance of Product Service systems and their suitability and value in the context of the Dutch environmental policy. This assessment should be made by means of a simple method that is easy for businesses and government to apply.

Scope of the report

This report is the result of a project that started in December 1997 and continued until January 1999.

The scope of this report is a company in interaction with its clients and suppliers. Although the main targeted audience is the industry, the report addresses policymakers of governmental organisations as well.

The report describes the concept of Product Service (PS) systems. Interesting business opportunities are illustrated, many of them resulting in a significantly lower environmental impact. The report investigates the value of PS systems as general concept for unlinking economic growth and environmental impact.

1. For governments understanding PS systems could ultimately lead to new instruments towards an environmentally efficient society.
2. For product-oriented companies, PS systems could offer new growth of business by adding services to their products with lower ecological impact in absolute terms.
3. For service-oriented companies, PS systems could open new opportunities to improve their connection to the physical world, by offering their qualities as service provider or expending business by adding hardware.

For all of these actors the tools presented in this report can clarify, at least in part, whether changing towards PS systems will result in a decrease of ecological impact.

How we have worked, in short

After a concise literature study and discussions with selected experts, we came to a set of basic definitions. Next we concluded to apply a set of four viewpoints for the assessment and description of any PS system: the economic aspects of the PS system, the ecological aspects, the company's identity and strategy and the market acceptance.
We developed a four-axes model based on this finding. Next, we invested to expand our ideas related to the economic and ecological aspects and their mutual relationship in PS systems making new models based on a model described in recent literature.

In the third step, ten selected cases were discussed in interviews with the representative industrial managers. These cases are all described in this report in a merely qualitative manner. From three cases the environmental/economic aspects were analysed quantitatively (but at a general level), in order to get an indication of the quantitative relation between economic potential and ecological impact.

General conclusions and recommendations were postulated as a last step. Parallel to this work, ideas were exchanged with specialists in the field of services, industrial innovation and product-design, from The Netherlands, Sweden, Germany, Belgium, USA, France, Canada and Italy. The annex '*Contacted persons'* lists the people we have spoken for this project. Further information can be found in the Annex *'How we have worked, into more detail'*.

Outline of this report

This report will provide basic understanding of the concept of PS systems.

Chapter 2 describes what we are talking about. Definitions are given here, e.g. for products, services, Product Service systems. Also a classification scheme for PS systems is given. Some social, governmental and business phenomena that stimulate Product Service systems are viewed.

Chapter 3 outlines a qualitative methodology that enables analysis of new or existing cases. The four-axes model including environment, economics, identity and strategy, and consumer acceptance, is introduced there. Next the chapter provides quantitative tools on two co-ordinates: environment and economics. This chapter closes by explaining a tool for looking at the potential for unlinking economic growth and environmental pressure.

Chapter 4 describes ten cases of real-life PS systems and a qualitative assessment on the developed 4-axes model.

Chapter 5 illustrates the quantitative analysis for three selected cases.

Chapter 6 gives general conclusions from this project and recommendations for future work to be done.

1.4. Why PS systems? Theoretical embedding and motivation

Before we will start to describe our ideas and work in the next chapters, in the last part of this chapter we will ask the reader to reflect on the structure and mechanisms of our economy. Why is it so difficult to unlink environmental pressure from economic growth? What strategies could be followed? This will explain the 'Why' of our work.

Understanding economic growth and value creation processes

World-wide, industry is spending money and human effort in making production processes cleaner and more efficient. So far, most companies and countries have been quite successful in solving more or less isolated environmental problems. There is an almost infinite list of examples: polluted rivers are clean again, packaging materials are collected separately and recycled, many process specific emissions have been reduced significantly (RIVM, 1997; EEA, 1996).

However, environmental benefits of improved technologies or products, can be counteracted by increase of consumption. For instance, the today's car is less polluting than the car of the 70-ties. Car emissions have been reduced drastically per km travelled. However, there has been an increase of the number of cars in our society and cars are more intensively used. Also, the average size and weight of cars counteract the positive engine development, as result of requested comfort, safety and functionality.
This simple example illustrates that the process of transformation towards increased sustainability includes the behaviour of all actors: producers and consumers.

The phenomenon of increased consumption that can counteract the efficiency benefits gained elsewhere is a quite general phenomenon. It is usually referred to as '*rebound effect'*.
We can distinguish two elements that contribute to this rebound effect:

- General economic theory predicts that the longer a product exist, the more items are produced. The product gets less scarce. Often, the number of competing producers will increase. Additionally production costs will decrease as result of economy of scale. Consequently, the longer a product exists, the cheaper it becomes and more people will buy and use it.
- Improvements that make products and services more effective (e.g. energy consumption) will generally lower purchasing cost or operational costs. The money a consumer saves will be spent elsewhere and reduced costs will attract new applications.

Both elements are closely linked to economic growth. In our socio-economic system, economic growth is considered as an essential requirement for prosperity and social stability.
In the Annex *'Reflection on economic growth'* we will reflect upon the basics of economic growth mechanisms.

On the one hand, economic growth is enabling producers to make investments in cleaner products and technologies. On the other hand, increased consumption is an obstacle for reduction of the overall environmental load. Economic growth and increase in environmental load seem difficult to unlink. It is clear that solutions need to include both production *and* consumption patterns. In the past emphasis was put on improving environmental performance of production. So it is time to shift focus to consumption: to start looking for sustainable fulfilment of consumer's needs.

Economic growth is linked to *perceived value creation* and not necessarily to material or product streams circulating in the economy.

> We have to find ways to increase the perceived value of all transactions without increasing the environmental load of products involved. The solution could be to dematerialise economy. One strategy for this seems a shift from an economy based on production and consumption of physical products to a services-based economy.

This is the 'working hypothesis' of this project. This hypothesis will be carefully checked. In the following paragraph a general check will be made at a macroscopic level. In the next chapters we will develop tools for more in-depth analysis at the company and production chain levels. Hereby, we will focus on PS systems (combined market offers of products and services).

Analysing the macro picture

In a macro perspective, we can raise the following question: *Can we analyse the environmental load per unit of economic value for different industrial sectors, and if so, are service sectors really outperforming industrial sectors?*

'First estimate' answers to this question have been achieved by the following approach:

- we have considered energy consumption use as representative for the environmental load of a sector,
- and we made use of traditional sector information of the Dutch Statistics Office.

The results of this analysis are given in Annex *'Reflection on economic growth'*. They show that *on average* services are to be preferred over products as a means to perceived value creation. However, there are many exceptions. This implies that we should analyse PS systems case by case.

An even more important notion is that the macro perspective of sectors does not cover the complete life cycle of products. Therefore, incomplete or false conclusions can be drawn on the environmental performance of sector activities. To determine sound strategies towards sustainable production systems, we need to include the 'chain perspective'.

These conclusions and the limitations of this sector analysis have guided us towards the methodology that will be elaborated in this report.

2. What are PS systems?

2.1. Basic definitions

We have experienced that in discussing products and services there is a serious risk of miscommunication. Therefore, we decided that it is important to share our frame of reference with our readers. We ask you to take notice of our definitions for a better understanding of our work.

We have found that there is not always full agreement on key definitions in literature. Furthermore, some of these are too broad for our purposes, other (classical) ones seem to be out-dated in the light of modern production and distribution patterns. Therefore, we have formulated our own set of definitions suitable for our project, based on literature and our ideas. These will be introduced and briefly documented below.

A product is a tangible commodity manufactured to be sold. It is capable of falling onto your toes and of fulfilling a user's need.

> A brick is a product, so is a computer or raw materials that have been processed by human activity. Other kinds of products are ingredients, like coffee powder or paper and auxiliaries.
>
> In our context, we skip the often-used second definition 'immaterial result of something'. Therefore, in our project a product is neither a happy customer nor a standard insurance policy. Traditionally products are said to be having a pre-defined specification. Today, the shift towards ultra-lean and flexible production networks offers a more open customer interaction. This property has eroded somewhat and is left out of our definition.

A service is an activity (work) done for others with an economic value and often done on a commercial basis. In this project, we include work done by human beings as well as by automated systems.

> Shoe polishing is a service; as is transporting buckets; and distribution of money through a cash dispenser (ATM).
>
> Literature shows numerous definitions of the word 'service'. A practical one stems from Prof. Bullinger of the Fraunhöfer Institute: *a service is anything you can sell and that is not capable of falling onto your toes.* Interaction between provider and client is often seen as a key item. Other descriptions concentrate on production and consumption occurring simultaneously, on direct contact between provider and consumer and on specifications being influenced by the end-user. Kotler and Bloom (1997): *a service is any valuable activity a party can provide, that is essentially intangible and that does not result in the ownership of something.* Krozer (1996): *A service is an element of consumption with a relatively high work or capital content.*

A system is a collection of elements including their relations.

> Elements can be material and immaterial. The hierarchic level, system boundaries and relations are defined mainly as a result of the researcher's aim.

A product system is a set of material products needed to jointly fulfil a user's needs.

> A microwave and cooking bowls make up a product system. All products in a kitchen too. In this project we regard food delivery services not to be part of the product system.

A Product Service system (PS system) is a marketable set of products and services capable of jointly fulfilling a user's need. The PS system is provided by either a single company or by an alliance of companies. It can enclose products (or just one) plus additional services. It can enclose a service plus an additional product. And product and service can be equally important for the function fulfilment. The researcher's need and aim determine the level of hierarchy, system boundaries and the system element's relations.

> Interface (a US based company) leasing carpets sells a PS system. A car dealer offering lease service too. Just like a GSM provider offering free GSM devices. So is the catering company on board of trains, using a dedicated trolley especially designed for the catering service. Examples of product systems *change* are: switching from analogue photographs infrastructure to digital imaging and switching from coins to virtual money (information embedded in magnetic cards, and in computer memories).

For practical reasons, in our project we have applied restrictions to the 'service part' of PS definition. The 'service part' has to come on top of essential and unavoidable service activities in the production chain and should contribute for a substantial part to the economic value creation. We will use the following restrictions:

1. Since we focus on unlinking economic growth from ecological impact, our interest lies mainly in services delivered on a commercial basis. This implies that we refer to activities with a direct positive economic value in the market place. Extra services offered for free (for instance to increase brand image or customer's loyalty) does not qualify for the PS system definition.
2. In PS systems we only regard services provided for benefits of end-users (end-users can be private consumers or businesses).
3. Common distribution and sales activities do not qualify for the PS system definition. Including them would have weakened the PS systems concept: the research field would have become too broad and included all products. Also, services like product-related advertisement and image building communication do not qualify. However we realise that increasing these service based activities will increase the perceived value and acceptance of products. The benefits and costs of all these shall, of course, be included in our analysis method (under economy and customer acceptance).

A product substituting service is a service that enables need fulfilment in such a way, that it brings a significant decrease in the materials component needed for the fulfilment.

> Philips Medical Systems switching from one-way to reusable packaging for their NMR scanners in hospitals introduce a product substituting service by taking back the crates. Video on demand by MTV, instead of buying pre-recorded videos in the local store can be resigned as a product substituting service too. 100% substitutes are quite rare. A singer replacing a jukebox could be an example.

Dematerialization is changing a user's need fulfilment in such a way that material flows and energy flow of this need fulfilment decreases significantly.

> Note that we have chosen to take both materials and energy into account in this definition.

The (environmental) rebound effect is the effect that the world's environmental load increases as an indirect result of a function fulfilment optimisation in both ecological and economic way.

If a car manufacturer doubles fuel efficiency, the environmental load and expenses per kilometre decrease both: a clear win-win situation. In absolute terms however, consumers will use their saved money for additional consumption that will have environmental impacts. This is indicated as the (environmental) rebound effect. The size of rebound effect depends on the behaviour of the customer and is hard to predict. Sometimes the saved money is spent in the same way (travel more by car having a large rebound effect). In general this is not the case. When spending the money in buying violin lessons, the rebound effect is small. When spending it on air flights, the rebound effect is large.

A value creating pool is a set of mutually connected economic activities jointly serving a user's needs.

The pool *washing clothes* contains activities such as selling machines, producing detergents, printing packaging, delivering drinking water, purifying water, recycling steel scrap. The pool *analogue photography* contains set of activities totally different from the pool *digital photography*.

Functional unit, or unit function fulfilment: a standardised quantity of measurable function fulfilled by both PS system and reference system.

A proper choice of the functional unit enables fair comparison between different design solutions. Functional unit will be a key word during the environmental and economic analyses of PS systems.

Blurred borderline between product & service

The difference between product and service is clear in most cases. Closer observation however shows a transitional area. This puts up the conclusion that product and service are to be regarded as two *means for adding value* (or function fulfilment).

Work done at a bank for a customer is definitely a service: a counter clerk starts working as soon as I get in, there is a direct contact between end-user and provider, and interaction influences the service specs. The automation of this (ATM) is regarded as a service too. As a contrast, an ice cream bought in a super market is commonly perceived as a product. Even if the ATM offers me eight different money sums while the supermarket offers me twenty types of ice cream and the store has to provide the service of cooling the merchandise.

Now how about databases and executing computer software? Service or product? Databases perhaps being a product (not showing any activity at all, they are dead collections of data). Executing software perhaps being products, since thousands of copies of the same program are sold without any interaction at all during the sale process. Or is an executing program a service since it is doing a job at my command with the specifications that I alone want, adapting to my personal need? For practical reasons, we regard executing software as a product.

It can be concluded that any tangible product contains a large amount of service-value embedded. All products have been built up by a series of services added to amounts of raw material.

2.2. Characteristics of PS systems

What's known about PS systems already?

Ecology-oriented philosophers and researchers have been a rich intellectual source to us (e.g. Factor 4). Long term sustainable concepts of Stahel and Giarini (1991), Manzini (a.o. 1997, 1998) and Jansen and Vergragt (1997) have been inspirational. Stahel has delivered the concept of the service society as a means for growing towards sustainability. Manzini proposes the strategic product system, involving product, service and communication, as a means for companies to present themselves to the market and participate in society. Jansen and Vergragt worked on

the DTO concept that crosses the company's borders and takes all relevant parties into account.

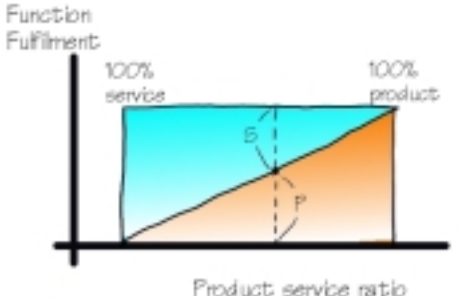
Related projects and groups

At the time of writing, a joint project commissioned by the EC is carried out by four research institutes in Germany, Italy, UK and The Netherlands on eco-services for industry. The focus is on renting, pooling, and sharing of durable consumer goods. No results are reported yet. We contacted the researchers and exchanged ideas and discussed our intermediary results.
The Institut für Zukunftsstudien und Technologiebewertung (Berlin) carries out a project on the role of services in efficient recycling. In Sweden the Servus Research programme focuses on need fulfilment opposed to product sale. At the time of writing, no results were available from these projects either.

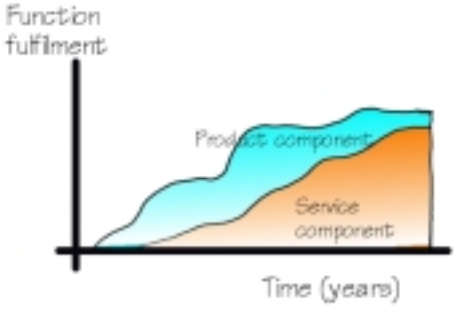
Suggestions came from German and Dutch projects. We made use of publications from the Institut für Ökologische Wirtschaftsforschung (IÖW Germany), the Wüppertal Institut on Material Inputs per Unit Service/MIPS (Germany, Schmidt-Bleek), Delft University of Technology on Function fulfilment versus product sale (Faculty of Industrial Design Engineering, The Netherlands, Meijkamp), and on business motivation to start environmentally oriented design (same Faculty, Van Hemel), The Loep Project on product life optimisation (CEA, the Netherlands), The Eternally Yours Foundation on product life extension (a.o. Achterhuis et al, 1997), Syntens The Netherlands concerning Design Plus Service (1997), The United Nations Working Group on Sustainable Development (Amsterdam) concerning a survey on Sustainable Service Design. We also noticed that the concept of PS systems is discussed by designers and environmental organisations (a.o. Teleac, 1998; O2, 1998, Milieudefensie, 1998).

Our concise international literature search and the additional interviews with Dutch, American, Australian and Italian specialists have brought us to the following conclusion:
Systemic integration of environmental load, business economics and client value design through PS systems is only found in a very few studies[5]*. Most of these studies are still ongoing and not published at the moment of writing. For the PS system concept we need to combine partial knowledge.*

What are Product Service systems?



A PS system is described as a marketable set of products and services capable of jointly fulfilling a user's need. The product/service ratio can vary, either in terms of function fulfilment or economic value. The first illustration shows a representation of this.



The P/S-ratio varies from case to case, but it can also vary over time, due to technological development, economic optimisation and changing needs of people. This is visualised in the second illustration.

[5] car-sharing (a.o. Meijkamp, 1997)

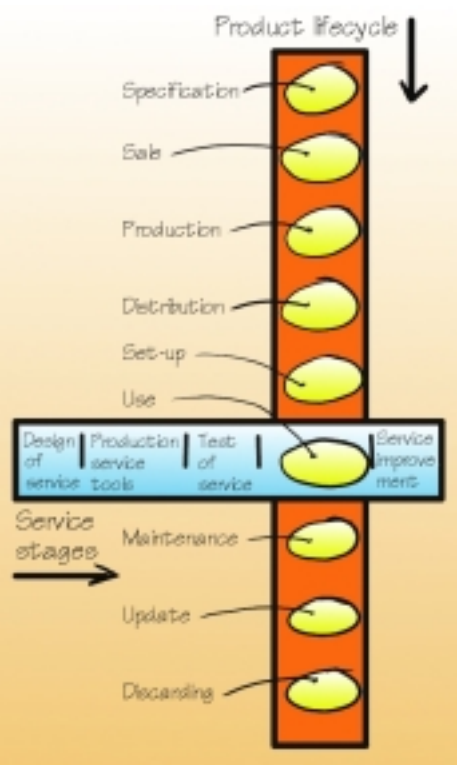
PS systems have unlinking potential

Different product service mixes can fulfil the same function. A new PS system with similar functionality can score a decrease in environmental pressure. In case this is combined with an attractive economic value of the new system, a system change has potential for unlinking environmental pressure from economic growth.

> In The Netherlands one can subscribe to a weekly deliverance of ecologically grown vegetables. Compared with traditionally grown and distributed vegetables, this is a different PS mix serving the eater's need. Chapter five shows the environmental impact is excitingly different in both cases.
> Today, digital photography is rapidly gaining market share. This means a totally different PS mix and value creating pool. No more vans driving from shop to photofinishing laboratories. No more silverbromide layers, chemical processing of films and waste management of film housing. From now on it's Flash ROM memories, e-mail and inkjet printers instead.

Positioning interactions of products and services

The relationship between products and services can be clarified by making use of the stages of the lifecycle. Visualising this leads to what we have come to call the *Product-Service Cross*. The vertical axis shows the product's lifecycle stages: specification phase, sale, production, distribution, installation (set-up), use, maintenance, repair, update (function extension) and the end-of-life management. Horizontally the design phases of the service are visualised: services are designed as well, tools are made for them, they are tested and redesigned, although the character of the horizontal 'creation' process differs significantly from the vertical one.



In the first category, services are connected to products. We will label PS systems in this category as *'Ps'*. More detailed labelling could be done according to the product lifecycle stage where the service is provided.

In a second category, a service provider can add products. PS systems in this category are labelled '*Sp*'. One way of more detailed labelling is to distinguish whether the product is handed over to the client, or whether it is used as a production aid for service provision. Example of the first: a free GSM set or a credit card. Of the second: an ATM cash dispenser.

In the third category, products and services are developed in combination to provide their function fulfilment (Code *PS*).

For the last group, innovation takes place by change of system, substituting a PS system by an improved system (Code *STCH*).

2.3. Driving forces for PS systems

Business drivers for PS systems

Service providers as well as product providers can introduce a PS system. On a company scale, the new PS system should improve business. Literature gives a good view on the major business drivers for introducing services additional to material products (for example Mathijssens, 1997).

For product-oriented companies, adding services is done in order to:
- escape from a commodity market searching for unique selling points (USPs)
- create superior value for clients
- build up direct customer relations, to intensify contact or to increase contact frequency
- supply a total offer: product plus lease service, plus insurance, plus ingredients, plus product upgrading, plus repair, plus call centre, plus take-back, plus refurbishing
- discourage newcomers by increasing the quality level throughout the supply chain
- anticipate or respond to new or expected policy, legislation or fiscal measures

> For example: subscription systems can be used to intensify client contact. Philips and Beiersdorff work together in Coolskin: a shaver with a subscription to the shaving lotion.

For service manufacturers, adding products is done in order to:
- protect market share (most services can be copied in a wink)
- reduce costs (automation)
- extend service
- communicate innovations (hardware innovation is easier to communicate than an intangible innovation)
- lower the (financial) entrance threshold for new clients

Some of the reasons for companies to reject a PS system are:
- the company’s unique selling points (USPs) lie in technical knowledge and product quality control rather than in providing service or vice versa
- for a service provider, the company's USP lies in direct contact with the clients, not in automation or product infrastructure
- the company is not large enough (in means of locations or in-house disciplines)
- the market simply does not accept the PS system

Eco-drivers for PS systems

Apart from business drivers, we have a special interest in the Eco-drivers. Some drivers are generic for environmental improvements (not necessarily being PS systems).

Generic eco drivers
- image improvement
- practising producer's responsibility
- covenants with authorities
- health and safety management (a.o. HACCP)
- practising societal marketing principles

- environmental costs reduction
- published product tests
- feeling responsible for the company's environmental load
- NGO and societal pressure
- green purchasing by authorities or consumers

Eco drivers specific for PS systems

We found in some cases specific drivers for PS system introduction:
- legislation threat, client's wishes, feeling responsible, image building and competitor's dominance (for instance in case of take-back systems, Te Riele, 1996)
- servicing client's environmental problems
- covenants with authorities
- green purchasing by authorities

With regard to Ecodesign, Van Hemel (1998) has found that in small and medium sized enterprises (SMEs), the drivers for Ecodesign success are merely internal stimuli. She shows *environmental benefit*, *cost reduction* and *image improvement* are dominant. Amongst external stimuli, although less important, *market demands*, *laws forcing* and *supplier developments* are most important. We have found that for innovations towards PS systems this last category is of much higher importance compared to the ecodesign innovations.

Identity drivers

Not every company desires to combine services with products. Not every company is capable of combining them. Not every PS system initiative is accepted by the surrounding network and the clients. Financial and eco-drivers are important, but identity issues like management style, company structure, employee properties and surrounding network characteristics play a key role too.

> The Ecodesign II program (by Syntens, The Netherlands) shows that in SME's the option of *changing the product-service ratio* is typically neglected by manufacturers, whereas it is mentioned by experts as a serious opportunity for environmental and economic gain in about 15% of the cases.
> An example: a small manufacturer provides wooden cases for moving high-value paintings. The company sells these cases to museums. Art museums tend to store them. Room is scarce, so museums have to destruct them every now and then. The suggestion that perhaps *renting* cases would be of more value to the museums than selling, was not picked up by the SME. Nor the suggestion that a safe & reliable transportation service of art objects might be offered instead of wooden products. Main reason: 'not our type of business'. Perhaps the company was right, but the financial chances were not even investigated (Meijkamp, 1997 and Brezet et al, 1996).

A product organisation differs from pure service providers. A service organisation can fully concentrate on a positive client's relation and satisfaction. Service organisations have a direct interface with end-users and therefore interact to a higher extend with the client.
At the end, a product organisation has the same goal, a satisfied customer. This is translated to a general strategy to make good quality products that meet the client's expectation. Therefore, much attention of a product organisation is focused on the development, production and distribution processes in itself. Generally, product organisations make use of many suppliers, and are more oriented towards intermediate organisations like distributors and knowledge sources.

Already we have seen in the Product-Service Cross that the lifecycle of products and services are different. The innovation risks are different. Development lead times differ dramatically, as do the innovation budgets (generally speaking).

Staff and supporting systems (like ICT networks) are selected to contribute to different core competencies. They will be different, or at least will be used differently.
Generally, for service organisations management styles are highly based on commercial data and motivating people versus more skill and controlling oriented styles for product organisations.

Trends matching the PS systems concept

The PS systems concept matches with global trends in consumption and production, as well as in government policy making.

For consumers it is the era of mass customisation. End-users select commercial offers that suit their individual needs at lower-than-ever costs. Fast deliverance is demanded from producers, retailers, logistic service providers, and other chain players. The client has come to regard product and service as two parts of the same commercial deal, thus blurring the borderline between product and service.

Product industry adapts with increasingly flexible production networks. Lean organisations serve quickly changing individual's preferences. Increasingly, the production chains are directly steered by actual market demand. In the sector of durable goods, it is already quite common that the consumer decides which products are being made (e.g. Dell computers) and the actual time of production. This is a major shift from the situation in the past where the producer made these decisions alone. In the new situation, you could say that the producer allows the consumer to make use of his production and distribution processes to afford the goods of choice. Services are regularly brought in, to bridge the gap between production infrastructure and individual demand. Services can contribute in improving the relation and communication between manufacturer and individual customer. Implementing new logistical tools and methods often based on information and communication technologies (ICT) can eliminate some links that were essential in the production chains of the past.

Global competition puts the product industry under severe pressure to shorten the design, development and production time, even of most complex products such as GSM telephones. The adequate use and introduction of new ICT-tools in industry is indispensable for surviving in this competition. The sequential introduction of new models and software induces a new need for assistance, training, update and take-back services.

Service industry makes more and more use of hard- and software to raise service level or to reduce costs. Efficiency will pay, as in Western economies personnel is expensive. Although automation of mass-services will eliminate people's jobs at first, the automation quite often results in a de-personalised (which means a loss of) contact. New ways to preserve the relationship with the individual client are needed. In traditional services (such as administration, accountancy, insurance) competition is increasing. Margins are under pressure so new concepts are needed. Recent developments within the IT industry have resulted in an explosion of new service techniques and service segments. PS systems can offer huge and stable market for specialised service providers.

As examples: internet services and service providers, car navigation systems need to be in contact with data that need to be kept up-to-date constantly by service providers, many new information and assistance services are provided by GSM companies.

In Western society, services, already vital for the gross national product, are gaining share.

In environmental policy, policy documents refer to the need for combined change of production and consumption habits. Visionary documents announce the need for system changes. The PS system concept introduced in this report can contribute in the realisation of these future scenarios.

Conclusions chapter 2

Definitions of common key words like product and service were given, based on literature. For contemporary words like dematerialization, product service system and product substituting service we have drawn up a new consistent set.
Relevant literature (e.g. environmental of services, PS business economic and value design through PS systems) is still scarce. However, several groups are carrying out valuable work.

'Product' and 'service' appear no entirely separated fields but rather two poles of the same axis called means for adding value. We offer some basic ideas and models.

Product as well as service providers can introduce PS systems. Driving forces can vary. PS systems can be driven by strategic business, ecological or legislative reasons. Today's (perception of) company's identity can be a serious drawback for introducing a PS system.

Last conclusion is that the PS systems concept and the opportunities that it offers matches well with trends in environmental policy and international consumption and production. Therefore, the timing could be right for the broader introduction of the product service system concept.

3. PS Systems: Analysis on four axes model

This chapter describes the qualitative and quantitative tools that were developed in this project to assess existing and potential PS systems. The qualitative tools are applied on 10 cases in chapter 4-, the quantitative tools are applied on three cases in Chapter 5.

The real value of a PS system cannot be determined in isolation. Assessment of a PS system should be made by comparison with a reference. Often this reference is today's leader in the relevant market segment. By making the comparison, you will learn about the relative strengths and weaknesses of the PS system on each of the four axes. The reference acts more or less as the 'mirror to the market' for the PS system. Selection of a good reference is a crucial element in each assessment.

First a clear description of the functions fulfilled by the PS system is to be made. Then the reference is selected and described by answering questions such as:

- '*Which alternatives does a client have?*' or
- *'Which competing systems are available in the market?*'

In the process of selecting a reference system, the following remarks can be of help:

1. Sometimes, the PS system can not be compared with a simple reference system available in the market. The PS system can only be compared with a set of individual products and services that have the same combined functionality to the consumer. But even if we can construct the same functionality, comparison can be difficult, as the PS system has important effects on the *convenience* level or on the perceived quality. For instance how do we compare fast delivery with flowers with super fast delivery of flowers? In some cases it is not even easy to match the function fulfilment of a PS system with a combination of other systems. A GSM telephone combines freedom and tele-speech, but it also helps you to memorise names and number lists, or even provide you with connecting services. So the mobile telephone can be compared with a combination of traditional telephone infrastructure, phones boxes, address book with telephone numbers and part-time secretary connecting with unknown numbers.

2. In contrast with these difficulties, for the environmental and economic assessment, the reference situation chosen should not be over-complicated, as this will make the analysis too difficult and time-consuming. Simplification is sometimes needed. This can often be achieved by asking: *'What is the essential property that the client is willing to pay for?'* In case the reference situation does not fully cover the PS system's functionality, this should be well documented. The extra features of the system should be rewarded in the strategy and identity and consumer acceptance analyses.

Comparing systems basically can be done qualitatively and quantitatively. First, we will describe a qualitative method for assessment.

3.1. Qualitative assessment using four axes

For the qualitative assessment, we developed our tools in such a way that they include the most relevant issues for companies, consumers and society. In the Annex *'Analysis of PS Systems: What do target groups expect'* these issues have been addressed. As a result, we concluded that PS systems must be assessed on four aspects:

1. *What are the environmental characteristics at function fulfilment level and how do these relate to overall environmental load on society?*
2. *What are the economic characteristics at company level, and at the level of the business sector ("the pool")?*
3. *To which extend does the PS system match the company's identity and strategy?*
4. *To which extend would the market accept the PS system?*

These questions form the basis for our 'Four-axes model'. In this chapter, we will explain how to work with the four-axes model and how to analyse the PS system for each axis.

We believe the four-axes model should be useful in two ways:

a) For analysis of already *existing* PS systems, on benefits for society as well as for the providing companies.
b) For assessment of *new* PS systems and fur guidance during implementation. Both authorities and companies are expected to be interested to do so.

In this project we could only test the tools for the assessment of existing cases.

Qualitative analysis is specifically of interest in the following situations:

- in the phase of idea generation,
- when quantitative computing would be too time-consuming,
- when crucial data are missing.

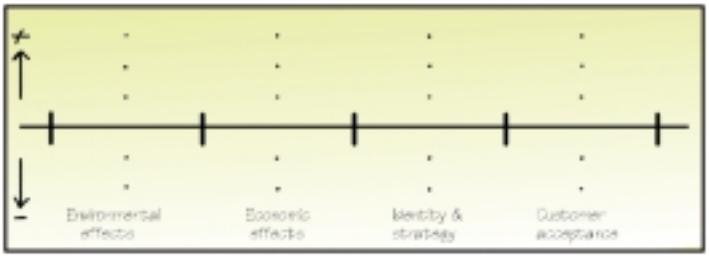
Goal of the qualitative analysis is to get a rough indication of the scores on all four axes, which however meets the required level of reliability of the specific situation. Before we will explain how to get reliable scores on each axis, we will first discuss the *process* of the qualitative assessment.

Expert panel

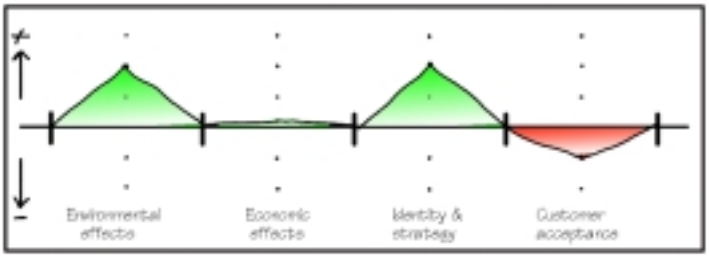
To compensate for the lack of quantitative data, it is advised to make use of a *panel assessment* by a multidisciplinary expert panel. These experts should have good insights in the case.

The experts discuss the PS system on each axis in comparison to the reference. On each axis, they give a final score, preferably on consensus basis. The advantage of the panel method is that all available knowledge can be taken into consideration and discussed, without the need of quantification first. Furthermore, the method allows 'soft' arguments such as management intuition. The quality of the results depends on expertise and mix of the panel team and time available for the panel discussions. Furthermore, the members of the panel discussion are expected to have an open mind and should not be too biased.

We have chosen to represent the outcome of this panel discussion graphically, as shown in the next diagram:



Each axis can be scored neutral, positive (1, 2 or 3) or negative (1, 2 or 3). A plus-score means: stimulating for introducing the new PS system. A negative score means the opposite. A neutral (zero) score mean that the new PS system does not affect this item.



In the overall assessment, these four items cannot be integrated to a single score, as each score is of a totally different nature. In spite of this, the graphical representation of the PS system offers a clear overview of its potential and weaknesses.

When the method is used for assessment of a new PS system, the final decision to accept or reject a PS system depends on the decision-maker's strategic goals and values. The assessment can be used to select the best alternative form a set of different PS system concepts, or to help focus on further improvements in the proposed PS system.

When the method is used for assessment of an existing PS system, the model summarises the relative strength of the chosen concept and may be of help for management to implement improvements or to develop appropriate commercial strategies.

Qualitative assessment suggestions

The qualitative assessment includes the following steps:
- formation of an multidisciplinary panel
- defining clear goals and boundaries for the assessment (company or production chain)
- describing the PS system
- defining a reference system
- assessing the PS system through comparison with the reference on each of the four axes
- discussing and evaluating the outcome
- final assessment, taking the pro's and con's into account. This assessment may lead to a quantitative assessment, starting the new PS system project, a further development of the PS system, or support programs for the PS system, etc.

As a test we have tried this within our project team after having in-depth interviews with representatives of the companies that offer PS systems. These have already been introduced in the market. These PS systems were selected as cases for this project and are described in the next chapter (including the results of our internal panel discussions).

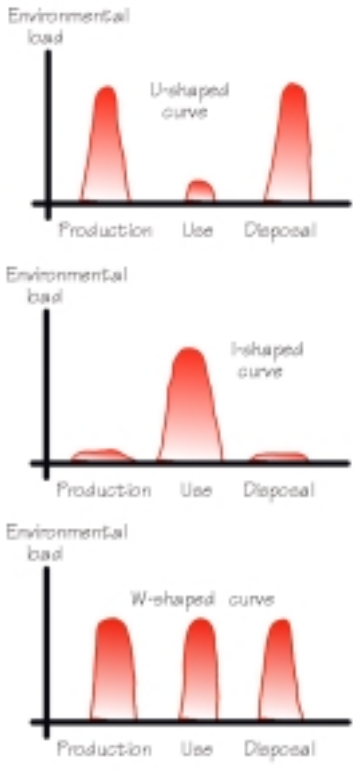
We will now start explaining how to judge the PS system on each axis of the 4-axes model.

The ecological impact qualitatively judged (Axis 1)

The relative environmental performance of the PS system is a score of increasing importance to both producers and consumers. The environmentally score is a measure of the effectiveness and efficiency of the system towards exploitation of natural resources, energy consumption and other environmental pressures.
A positive relative environmental score contributes to a good image. It may offer additional advantages: the system could be targeted into the 'green' market segment, or could offer financial advantages in the future as taxes on energy and waste are constantly increased in almost all countries.

To avoid environmental sub-optimisation, it is usually advised to determine the environmental score at the chain-level (life-cycle level), although basically it is no problem to replace this by the level of company only.
Experienced environmental specialists, with experience in Life Cycle Assessment (LCA) studies, should be included in the panel team that gives the environmental score. They should pay attention to the bottlenecks in service based systems as explained later.

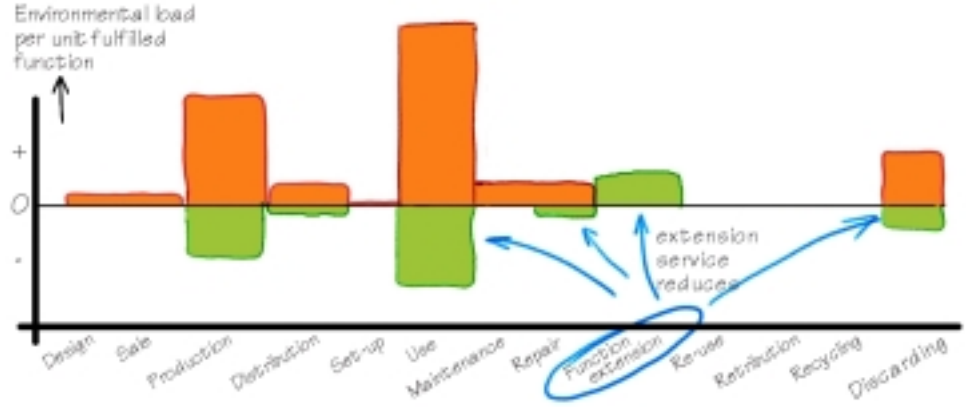
The first step in the qualitative analysis is the determination of the lifecycle phase with the most dominant environmental effect for the reference system. This results in a lifecycle profile as shown below. The next step is to determine how this profile is expected to change when a PS system is introduced.



Three main types of environmental life cycle profiles exist for products:

- *U-profile*. This is the case where environmental burden is caused in the production and end-of-life of the product. This product 'does' nothing during its use. Examples are packaging, building materials etc.
- *I-profile*. This situation is very common as well. In this case, environmental burden is caused during the use products. These products mainly have energy consuming functions like cars, televisions, light bulbs and buildings. For example, stand-by equipment is a large-scale consumer of energy.
- *W-profile*. Over here environmental burden is caused at all stages of the life cycle of the product. Examples are pens, scarcely used energy devices such as the lemon press or consumer goods that ask for constant care such as clothes and bicycles.

By shifting to the PS system, at some stages in the life cycle environmental pressure increases while at other stages, the environmental pressure decreases. Of course, most interesting cases arise when the overall environmental pressure (per function fulfilment) decreases.



In most simple cases, the service is added to an existing product, new environmental burden will arise because of the service, e.g.:
- the extra mobility by a repairman or delivery service,
- the impact of or by serviceman installing software or hardware updates,
- solvent emissions because of repainting in case of furniture refurbishment.

However due to the renting, sharing, delivery, repair, update or repainting, the life span of the product is prolonged or multiple consumers can share the product. Overall, the environmental burden expressed can either increase or decrease.

In the case of introducing a completely new PS system, the situation may turn out to be more complicated as the environmentally picture may change completely.

The economic effects qualitatively judged (Axis 2)

The qualitative economic analysis should both include:
1. the potential of the PS system to compete successfully in *existing markets* based on costs and revenue comparison with the reference system,
2. the potential to create *new markets* as result of the added perceived value of the PS system.

When assessing the competitiveness of the PS system, we should take both the producer's and client's perspective into account.
- The producer is striving for the highest revenues against lowest costs and risks. The economic analysis for the producer should focus on costs, that should be balanced by revenues. These include development costs, market introduction costs, advertisement and communication costs.
- The consumer provides the revenues of the producer. What is the price that the consumer is prepared to pay? He wants value for money. So, in first estimate we may assume that the price the consumer will pay is the same as in the reference system, as calculated on basis of a unit of ‘fulfilment of function’. However, this picture might be to simple, as the PS system often adds quality. In this case, the value perceived by the client may be higher and a premium payment has to be included in the economic analysis. As the price a consumer is willing to pay is influenced by the total offer, following aspects should be taken into consideration:
  - influence of costs saved or paid later during the lifetime of the PS system;

– positive or negative effects to the image of the client provided by the PS system.

Depending on the goal of the study the economic characteristics of the PS system can be analysed at two levels:

- *Company perspective: the object of analysis is the organisation or alliance that introduces the PS system. The company perspective is rather straightforward and asks for a logical analysis of all changes in costs and revenues. The company perspective is essential for any investment decision.*

- *The "business sector" perspective: the objects of analysis are all mutually connected economic activities in the business sector of the company. We include this perspective in order to show the strategic possibilities for companies to generate value and profit in other sectors than those that seem obvious. We believe it is very important to get an overview of the "pool" of alternative business decisions before deciding to embark on a new venture of creating PS systems.*

Economic analysis at the business sector level

A very interesting way of looking at business alternatives is the Profit pool concept described by Gadiesh and Gilbert in the Harvard Business Review (Gadiesh and Gilbert, 1998). *Profit pools* can be helpful to identify the business activities in a market where the profit is made.
The key of a profit pool analysis is the composition of a graph in which all relevant commercial activities in the business area of a company are plotted. It is up to the compiler of the pool to determine which business activities are to be included.
For each activity, turnover is plotted on the horizontal axis and profit margin is plotted on the vertical axis. The profit pool clearly shows the places where money is being made. For this the operational profit, or the return on investment is used, but also other definitions of the term profit can be used. The example shows that for some economic activities the value creation is high, while the margin is low and vice versa. For an in depth description of the profit pool we refer to the original article by Gadiesh and Gilbert.

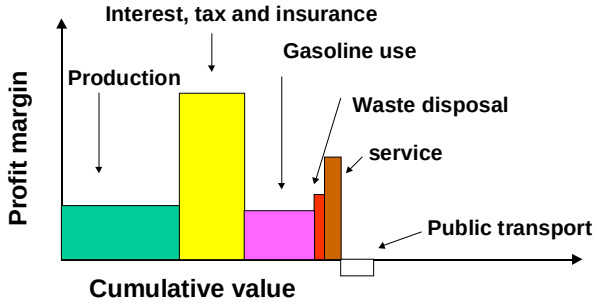


Illustration: **imaginary** profit pool for a car, using the lifecycle perspective (this does not need to be so). Several actors in the pool add value. Each activity has a different value creation and operational margin. *Service* brings just a small turnover, but a high margin. Thus for a car company, this may be a profitable service to add. Financing and insurance may be interesting too, e.g. for the producer of cars

Later we will see how the profit pool approach can be adapted in such a way that it is highly suitable for assessing the economical and environmental aspects in a life cycle perspective. In the original concept of the profit pool, the lifecycle concept is not used, but there is no reason not to use it.

For the qualitative analysis however, we recommend to use the profit pool in its original form. This means one can choose to plot not only the PS system, but any other business alternative that seems to be in reach of a company in the graph. This will allow the analyst to compare the PS system with other alternatives and to get a judgement on the value (turnover) and profit creating potential of the system.

If the profit pool perspective shows that the PS system is indeed a favourable option, the economical axis deserves a high mark.

Profit pool concept as tool to find most profitable markets

Gadiesh and Gilbert illustrate how the profit pool can be used as a tool to search for more profitable business activities in a highly competitive market. They show that it is often more important to have a larger share of the profit than a large share of the market.

Two examples, presented by these authors that refer to the introduction of PS systems:

1. U-haul is one of the USA's largest consumer truck rental companies. Traditionally U-haul and its competitors concentrated on cost control in order to provide the best prices in this highly price competing market (operating margin in this sector is typically 3%). However, recently U-haul reports an operational profit of 10%. This remarkable achievement was obtained by integrating services consisting of boxes, insurance, rental of trailers and storage space. The basic idea is that, although consumers shop for the lowest rates when selecting a rental truck, they are *not* very critical towards the price of extra services. In fact, once they have signed the rental contract there is no competition anymore, as they have been become captive of U-haul.

2. Dell has always been strong in selling computers directly, but around 1990 the company started to sell computers via retail channels. The growth strategy worked: the company grew 50% per year between 1989 and 1993. However profits declined and in 1993 the company reported losses. From that experience they concluded that although the market share increased, the share in the total profit pool had been eroded. After carefully examining the profit pool for their industry, Dell pulled out of the retail marketing. By now they achieve an operating margin of 9% (three times the industries average). In fact they now earn 10% of all the profit that can be made in the industry. Dell does not aim at market share but profit share.

When the profit pool concept is used as search tool, the search can include any activity that has a good match with the current position in the market. For instance, a second hand car dealer is probably not interested in analysing the opportunities to produce cars. However, he could be very interested in analysing opportunities of servicing, hiring, leasing or disposing cars. It is up to the business or researcher to define a pool that is wide enough not to overlook opportunities and narrow enough to keep the analysis manageable. In this respect, the application as ‘search tool’ is different to our use of the profit pool concept in the qualitative and quantitative economic analysis of PS systems closely linked to function fulfilment.

Identity and strategy qualitatively judged (Axis 3)

The identity of a company, the skills and qualities of its employees and the relative power of its surroundings actors (suppliers, competitors and authorities) may largely influences the company's decision to introduce a new PS system. Most of these factors relate to the operation of the company over a long period of time. They include key management issues like management style, company structure and values, ways of hiring, training and rewarding personnel and the ways of building and managing relationship with actors in the surrounding network. The situation of today should be accepted as the starting point for tomorrow. Good insight into the company's identity and its strategic position is a prerequisite for a sound analysis of the chances of the company to achieve the defined goal of successfully introducing a PS system (or to shifting from products to services).

Do I wish? Can I? Do they allow me?

Not every company *desires* to combine services with products. Not every company *is capable* of doing so, and the surrounding network accepts not every new PS system initiative. Therefore, three issues are worth analysing:

- To what extent does the PS system match with the company's strategy?
- Is the organisation capable of introducing PS systems?
- Do important third parties accept the PS system?

Strategic motives for PS systems

What business am I in? What value do we deliver to our clients? What are we good at? The PS has to show a good fit with these questions. Our case studies show that identity drivers can be very strong and often are important.

Is the organisation capable?

The introduction of a PS system needs the combined strength of a traditional product manufacturer and a traditional service provider. Some specialists state that no organisation can combine the capacities needed for producing products as well as services in their eyes. Since we see counter evidence in the market, we don't follow that statement. There seem to be two potentially successful models: alliances or integration of the missing competence into the own organisation.

> One example of a viable alliance in the market is the EMS Techno courier service. With this service, couriers do not only deliver computer components, but also install components or repair the computer. Laser Computers uses the EMS Techno Courier as an extra marketing instrument. Hewlett Packard uses this service in big, time limited projects.

Matching missing competencies

In most cases a manufacturer adds a service, the company needs extra communication with clients. Often new decentralised service-providing centres are needed. Training, motivation and constant introduction of new marketing and sales techniques become key competitive factors. As services can be (and *are*) copied in an instant, the value of a services merely lies in the quality of the organisation structure providing the service and the established network of clients. Patents are no longer of use. Time-to-market period for pure service organisations is typically three to six months with very low capital investments. For comparison, tangible product developments ask one to even fifteen years. This leads to a very different management and development culture. When introducing services, the manufacturer has to learn to pick up new ideas from the market fast.

Service organisations often need a quite civilised *front office* where the interface with the client lies, plus a heavy *back office* to take care of administrative processing. Alliances with specialised front office service providing organisations could offer solutions that could accelerate the introduction of new systems. However, often alliances with these companies are regarded as a threat. For instance, the facilities of banks and lease companies are often distrusted.

The table below can be used as checklist for the strategy analysis. This table shows organisational differences between the traditional product and the traditional service organisations. With this table in mind, answering the following three questions will show to what extent the organisation is capable and ready to introduce the PS system.

- *To what extent are the company's structure and level of decision making appropriate for sale and after-sale care of the PS system?*
- *To what extent do the employee's skills, knowledge and attitude match the demands of the PS system?*
- *Is the company's innovation routine capable of renewing products as well as services?*

Traditional organisational differences between pure service and pure product organisations *(Archetypes, composed from various literature sources)*		
	Pure service providers	**Pure product providers**
Product and client interface	– Intangible product – Easy to copy – Specified interaction with client – Direct interface with end-user – Client relation is the core	– Material product, often with standard specification – Intellectual protection (patents) – Indirect interface with end-user; often via intermediates
Organisation	*Servuction* organisation: – Heavy administrative department – Heavy process optimising department – Heavy information management department – Flat organisation – Decision making is more decentralised Orientation of organisation: – Towards end-user – Towards competitor	Production organisation: – Heavy hardware production department – Heavy product development department – 'High' organisation – decision making is centralised Orientation of organisation: – Towards distribution channels – Towards sources of technical knowledge
Marketing and PR	Aims at trust and trustworthiness	Aims at informing on product specifications and qualities
Employees	– Discipline-integrating during client contact – Communicating – Civilised	– High degree of specialisation – Controlling measurable quality
Management style	– Well aware of employees being the company's investment capital – Improvements aims at process improvement; at the way the company is *perceived* by clients	– Controlling product quality – Improvement aims at product quality improvement
Innovation routine	– Mostly centralised – Short lead-time – Little formats in innovation routine – Small investments – Extreme Me-Too conduct (copying, not developing) – Cross-selling	– Mostly de-centralised (business units) – Long lead time – High financial risk – Using project management tools – Thorough testing
Systems (automation, assessment, information management, etceteras)	Facilitating the above mentioned	Facilitating the above mentioned

The introduction of the PS system can bring a lot of changes to the internal organisation. The analysis should determine the expected rate of success and the way to move forwards. Not always it is possible or wise to change slowly and stepwise. In some urgent situation, destructive innovation[6] is needed to survive in the longer term. If so, often a new and relatively independent organisation needs to be build up.

Role by third parties
As we have seen in chapter 2, PS systems will sometimes find strong support by environmental policies. On the other hand, authorities and certifying or standardising organisations can influence market conditions or can slow down the introduction of a PS system. If the new PS system changes existing structures, such as the distribution network, a powerful distributor can seriously put you under pressure and threaten the PS system's chances.

All kinds of external actors can be driving forces of the PS system. On the other hand they can also block the system with success. Therefore, it is important to trace all external actors that could act as driver or obstruction to the market introduction.

This can be done by the following procedure:
Step 1. Make a list of all actors that play a role in the old and new situation, excluding the producer and customer (customer acceptance will be studied in the fourth axis of our model). This list has to be prepared case by case and can include local, national and European authorities, distributors, competitors, environmental groups and press.
Step 2. Imagine what kind of changes the introduction of the PS system would bring to each of these actors.
Step 3. Predict the reaction of each of these actors and the actor's opinion on the changing situation. When needed, estimate their power and influence.
Step 4. Check whether parties should be informed in an early phase, or even included in the system.

In case a competitor decides to introduce a new service or product that offers extra convenience to his clients, you have to decide how to react for not risking loss of market-share.

Customer acceptance qualitatively judged (Axis 4)

How do clients react to product-service innovations?
Are customers willing to change from buying products to consuming PS systems?
Do they appreciate the new features of a PS system compared to the old product?

Or rephrasing these questions in terminology of Kotler (1997), using his 5P-approach, will the total offer (consisting of product/service, price, package, promotion and place) be accepted by the market. If so, what selling arguments in the PS system's offer contributes most to the actual change of behaviour to become a client of the new offer?

[6] Destructive innovation (a.o. Clayton Christinson): an innovation that cannibalises the company's current products, knowledge and market share. Sometimes necessary to defend from new-comers using new technology

Between countries or even regions a difference in acceptance is possible. Skala television rental is big in the United Kingdom, while in the Netherlands it is a niche market player only. The market acceptance for sharing a car in the Netherlands is bigger in a city like Amsterdam than in smaller cities and the countryside.

How does a company sell a PS system? PS systems are sold by their *perceived* characteristics (Siderius, 1992). Similar to the sales of services, several arguments or characteristics of a PS system turn out to be important:

- Functionality
- Financial benefit on short or long term
- Comfort improvement
- Status improvement
- Reduction of complexity
- Tryability
- Fit to attitudes and values of the customer

Especially in the case of added services, new questions could be important:

- Do clients accept the closer relationship with the producer?
- Are they charmed by the total-offer-idea? Do they recognise the PS system as a superior value?
- Are signals for innovation picked up sooner by the PS system-provider?
- Has it become possible for the manufacturer to identify the individual's needs?

Determine the market segment and customise the PS system

The realisation of consumer acceptance for a PS system is a complex process. Key elements are a good knowledge of market characteristics, and a good set of features of the market offer. Features should closely match demands of selected market segments.

For the introduction of a new PS system, a general procedure that can be proposed to maximise consumer acceptance:

Step 1. Determination of market segments where the PS system could be introduced with a reasonable chance of success.

Step 2. Determination what selling arguments are most highly appreciated by the customers in each of the selected market segments.

Step 3. Matching the PS system's offer to the demands of these customers and trying to get a clear view of all advantages and drawbacks of the PS system, compared to the reference system.

Step 4. Estimation of the expected rate of acceptance for the PS system in each of these segments to provide reliable market input data, needed for the economic analysis of the second axis.

In case of assessing customer acceptance of a PS system that has already been introduced, part of the job is rather straightforward: an effective way to determine selling arguments for the customers already won, is asking these clients what features of the PS system they like most. However, to determine additional potential for new markets the situation is more complicated and more or less similar to the introduction of a new PS system. This situation will be described next.

Each customer has its own characteristic wishes and needs. However, customers can be clustered into rather homogeneous market segments. The introduction of the PS system should be clearly defined in terms of the targeted market segments, as this will be importance in establishing matching commercial offer. It makes quite a difference, whether the producer aims at a volume market or a niche market with a high added value.

Furthermore, situations for the introduction of a PS system can be differentiated according to the available knowledge of the market segment. Ranging from the introduction into a well-known market of existing customers to a launch into a new market segment with (still) unknown customers. The more you know about your clients, the more you can customise the PS system's features to their demands, thus increasing perceived value. The less you know, the more market research is needed to reduce the risk of a failure.

This situation is quite common. It could arise when the PS system is introduced into an existing market, either to displace today's product or to create a new offer with new features (cheaper, higher convenience, etc). The reason for the introduction could be a better profit margin, or to increase customer loyalty. In this situation, the clients are known, as are the features of the old product and its competitors. In case of product displacement, it is strongly advised to ask the clients whether they will accept the PS system, before the actual transfer is made. By termination of the existing offer, the producer takes the risk of loosing a customer.
To win customers for the PS system, the producer should see that his new offer is perceived as equal or better that the alternatives. In the first case, the PS system could even be introduced at a higher price than the current offer.

Introduction of the PS system into unknown markets

The new features of the PS system attract new customers. It is quite common that the new interest is coming from a new market segment. The company needs to identify the characteristics of these clients. Characteristics of the potential clients to be described are socio-economic situation, personalities, and communication behaviour. In order to assess these characteristics the company can use questionnaires, interviews, theoretical models, client discussion groups, or even more advanced techniques.

Market approaches

The promotion and communication is integral part of the PS system, offered to the market. Thus, costs of promotion and communication are included as standard production costs in the economic analysis of the second axis.

In some cases, PS systems are complex and thus difficult to explain. This complexity will result in additional cost for communication and a slower market introduction. To eliminate complexity, some companies prefer to innovate stepwise, by adding a service to the traditional offer. American designers like Loewie and Dreyfuss already in the fifties stated, that customers are often more perceptive for step-wise innovations than for the leaping ones. They called this the MAYA-principle: the most advanced, yet acceptable innovation.

Whenever the provider of a PS system knows both his potential clients, their wishes and the PS system's feature, a marketing campaign can start. Communication is essential to demonstrate trustworthiness, similar to pure service providers. Client's trust is the basis for sale. Brochures, corporate image and ads are designed very carefully.

Popular common market approaches are:
- wide propaganda towards a big potential clientele
- direct approach of existing clientele
- direct approach of relations of existing clientele
- personal contacts between company and potential customers, e.g. by telemarketing or salesman visits
- discount strategies

Assessment of the customer acceptance

At the moment of the assessment of the 4-axes model, it is assumed that the producer has already selected the optimal mix of features of the PS system, including the communication and marketing strategy. In the assessment, the best offer the producer could think of will be tested against the reference system.

It is advised that assessment by marketers and the sales personnel is included in the analysis of the score on the customer acceptance axis.

A simplified four-step process can do this assessment:

Step 1. Rank most important features of both offers. These are the features that the customer in (potentially) successful market segments definitely requests or appreciates most.

Step 2. Score the PS system and the reference system according to these features.

Step 3. When the score of the PS system in Step 2 is good, check whether the proposed communication and marketing strategy of the PS system is expected to be effective.

Step 4. Determine the relative strength of the PS system.

3.2. Quantitative analysis of first two axes: introduction

In this project we have developed methods to quantitatively assess the environmental and economic axes, but we have not done so for assessing the axes '*identity and strategy'* and '*customer acceptance'*. Emotion, experience and instinct play an important role in these two scores two right axes and these are virtually impossible to quantify. In stead we propose to use these axes as go/no-go criteria when contemplating the introduction of a new system. As we have explained before, they are a kind of traffic lights. It is important to check that both traffic lights are green, before the quantitative environmental and economic analysis should be started.

> 'Red traffic light' example
> The bike-rental service offered by Interliner Bus Company.
>
> This service was expected to be sold to commuters travelling long distances as a means of pre and post transportation. Environmental score would have been positive. The bike renting would provide additional service to clients, would have solved a major drawback of public transportation and would have matched with identity and strategy of Interliner. Unfortunately during the first year just one single bike had been rented, so the service was stopped. Customer acceptance was definitely low. Close prior assessment of customer acceptance would have saved a lot of money and time.

3.3. Quantitative assessment of the economic aspects

There are two ways to assess the economic aspects. The most obvious is the assessment at company level, a more exciting perspective was found using the profit pool concept.

Economic analysis at company level

Preceding the actual PS system development project, a project has to be assessed according to the accepted set of corporate investment criteria.
Service providers generate income at the moment of service providing. Product manufacturers generate money at the point of sale. This means although investment patterns can be similar, revenue patterns and total income can differ. The time horizon for computing is set at the sum of the development time plus the estimated lifecycle time of the PS system to compensate for both this difference and the time lag between costs and revenues. Traditional accounting methods can be used.

The annex '*Estimating the economic merits of a PS system project within a company'* offers a general scheme for this. The result of the analysis is a decision tool for the board of directors.

Economic analysis at the profit pool level

As we have seen in the qualitative discussion of the 4-axes model, the profit pool is a key element for the analysis of alternative business activities. However, we have found we can also use the concept to analyse business activities in the lifecycle perspective.

A profit pool analysis requires three steps:

1. Define the elements of the value-creating pool on the horizontal axis
Choose which activities should be included in the pool, according to the function fulfilment analysed.
The activities may include the value creating chain (from product cradle to grave), but this is not necessary. Setting the pool boundaries requires a good "feeling" for the goal of the analysis, as there are no straight criteria on what to include and what to exclude.

2. Quantify the value created in each pool activity
The volume and financial contribution of transactions must be estimated for each value creating activity. This will result into the total value created by all activities in the pool, and the (estimated) value creation of the individual products and services.

3. Determine the profits in each pool activity
Profits (operational margins) generated must be estimated for each of the activities. This results in an estimated total profit realised within the pool, and in the estimated profit of each production and service.

After determination of value creation and margins, the profit of each activity can be calculated and presented in a graph. In this graph on the horizontal axis the value creation per activity is given. The horizontal axis can be presented in percentages of the total value creation as well as in a monetary unit. On the vertical axis the margin in percentage is given.

The calculations should be repeated for the reference system. Comparison will learn which of both systems is most profitable and creates most profit and value, in the relevant parts of the lifecycle. If a PS system is developed by a strategic alliance of companies, the profit pool can also show how much the partners can benefit from their contributions to specific parts of the lifecycle

3.4. Quantitative assessment of the environmental aspects

As we have seen, the economic aspects can be assessed in two ways, the traditional company oriented approach and the profit pool approach. When we want to analyse the environmental aspects in a quantitative way, we also used two alternative perspectives:

- The traditional LCA approach
- The Eco-pool approach, based on the profit pool.

As we will see the Eco-pool approach can be used in a similar way as the profit pool; it allows companies to look for business opportunities that cause a relatively low environmental load.
Later we will see how the Eco-pool approach is used to develop a synthesis between economy and ecology in the so-called E2 vector.

First however, we need to discuss the application of the traditional LCA methodology for PS systems.

The use of LCA for PS systems

As a starting point we will first have to explain briefly the theory of environmental LCA, as we will make full use of life cycle thinking. The application of LCA for PS systems is discussed in more detail in Annexe 6.

Measuring a mental construct

There is no single, easy-to-use and generally accepted environmental indicator (yet):

1. *The* environment does not exist. The term 'environment' is a mental construct in which anyone can include almost anything that has to do with nature, health, future welfare, etcetera.
2. Scientific knowledge of the processes in nature that keep our ecosystems healthy is very limited yet. Humankind is just beginning to grasp the basic relations.
3. Our ability to analyse the exact interaction between product lifecycles and the environment is very limited too.

The most systematic way to analyse the interaction between a product and the environment are methods based on LCA methodology. This methodology is far from perfect and complete, however proves valuable in many cases. Moreover, there is no better alternative when dealing with environmental effects in a systematic way.
We use two methods, for reasons explained in the annexe.

1. Default method is the *Eco-indicator 95* method (Goedkoop, 1995). Although far from perfect, this approach is reasonably accepted and it includes most effects that are related to emissions. It does not include raw materials depletion or the effect of land use caused by roads and for instance final waste.
2. If this method overlooks or distorts aspects, or if no data are available, it is advised to use *energy*, as an indicator for all effects, and in some cases the *amount of waste*.

LCA's applied on PS systems

In the analysis of PS systems we will discuss some particular points of attention in these cases especially in relation to the functional unit:

- **Quality aspect.** As we have seen at the start of the qualitative analysis, it is difficult to define the exact functionality of PS systems, as such systems often include rather intangible elements to the product.

– **The inclusion of changing behaviour patterns.** A particular difficulty is the role of consumer behaviour. When we want to compare the situation before and after the introduction of the PS system, we must be aware of the fact that the consumer behaviour will probably change. For instance, the introduction of a carsharing system will certainly cause changes in the way some people will use cars, bicycles or public transport. In a traditional LCA approach this is too often neglected.

In LCA the functional unit must be described in such a way that it is relevant for the purpose of the study (ISO 14040). This means we have a wide range of options to choose:

- In a narrow definition we compare transport systems on a basis of a certain transport distance. For instance, we compare the environmental effects of a passenger km of a car in comparison with a passenger km on a train.
- In a wider definition, we can compare the environmental effects of two persons travelling the same distance, using a car or public transport during a month. In this analysis, we would include trains, busses and perhaps bicycles.
- In a very wide definition, we could use the actual monthly transport activities of two persons, one car owner and one that does not own a car. In this analysis, we can see differences in transport behaviour, in use of public transport and bicycle etc.

The advantage of the narrow definition is that it is very well defined, but the value may be limited, as it is focused strictly on technical aspects. It does not show that usually people have to make efforts to get to and from the station. The second, wider definition is more complete, but also more uncertain. It gives a better picture on the system, for instance if we want to compare options for commuters.
The third option is the definition that allows us to include the behavioural aspects, for instance that car owners usually drive more often. In case you make use of the wide definition you should strive for equal levels of consumer satisfaction in both situations of the comparison. Poor men without cars will travel less than rich men with Mercedes' will. However, as levels of satisfaction will differ, this is no basis for a fair comparison. It is best to search for situations of similar free choice.

The LCA methodology does not prescribe how wide the perspective should be. Each choice of perspective can be justified, when it is compatible with the purpose of the study and the information needed is available.

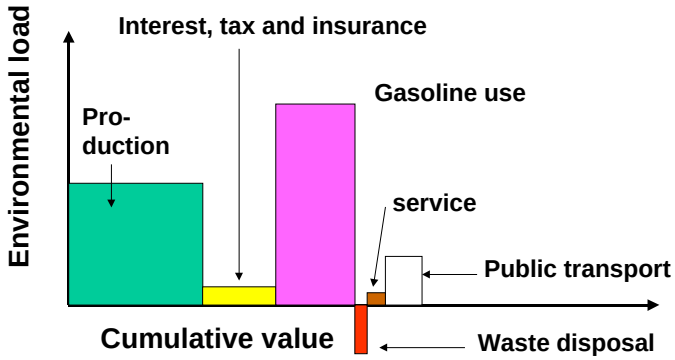
In case of the analysis of PS systems it is advised to choose a wide definition of functional unit. This is necessary, as the introduction of PS systems will have many and perhaps unexpected effects on other product systems. By choosing a functional unit that includes all or most of the systems to be affected we get a complete picture on the changes. Thus, in our analyses in chapter 5 we have chosen for a very wide definition of the functional unit.

Other problems
Other methodological problems include the inclusion of human labour, capital goods and some specific allocation problem. These are described in the annexe.

In spite of the fact that these points ask for extra attention, the LCA methodology seems to be a valid and suitable systematic way to analyse PS systems in the lifecycle perspective. Consensus on how to deal with these problems is growing as the ISO process has already produced one standard and two draft standards (ISO 14040, ISO 14041 and coming soon: ISO 14042).

The Eco-pool concept

Similar to the profit pool concept we can also plot the environmental impacts of economic activities against the cumulative value that they create.
The basic concept is the same as in the profit pool; the only change is that in stead of using the profit margin, we use the environmental load on the vertical axis. In the example below we have plotted an imaginary Eco-pool for a car. Again a lifecycle has been used to define the pool, but this need not to be so.
We suggest to use the Eco-pool as an addition to the profit pool. Once the profit pool has been defined, an LCA practitioner will be able to generate an Eco-pool of the alternative business options a company has.

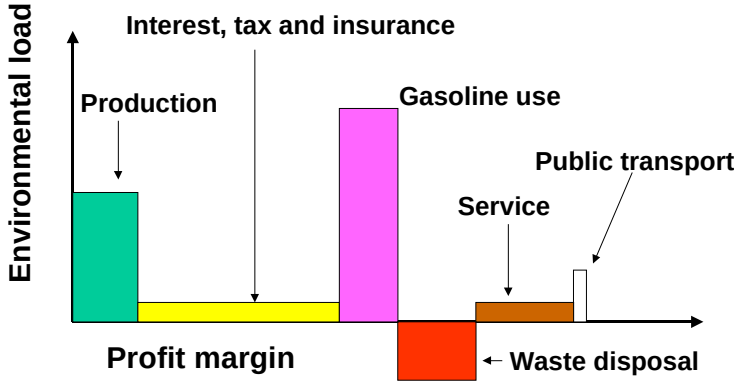


Imaginary Eco-pool for a Car. The use of gasoline generates a relatively high environmental load. Other business opportunities, such as financing and insurance, or service and waste disposal generate a much lower environmental load per unit of value.

Shifting to activities with lower environmental pressure

This Eco-pool can be used similar to the profit pool. Instead of looking for sectors with maximum profit, industry can search sectors with a minimum environmental load. By reorganising their business, they can shift into a direction in which they have the lowest environmental load share of the pool they are in, this leaving other industries in a position where they have a much less favourable performance. On the long run this could be a serious threat for industries when governments and consumers start to realise that these sectors produce a high environmental load while adding little value to the economic system.

One can also plot the environmental load against the profit in a single graph. This perspective is interesting for business as it shows the opportunities to maximise profit at the lowest environmental load. If environmental aspects of businesses are really taken seriously, it will be a strategic advantage to base the business profits on activities that have a low environmental load.



Further development of the Eco-pool concept for the assessment of lifecycles

In the first part of this chapter we have shown how the PS systems can be analysed on 4-axes model in a more or less qualitative manner. Secondly, we have shown how to quantify the economic and environmental effects of the introduction of a PS system, on basis of the profit pool and Eco-pool concepts explained before.
Until now we have been looking at how a business can analyse its profit and its Eco-pool. The developers of the profit pool allow the performers of the analysis to determine which business activities are to be included. Similarly, the Eco-pool can present the environmental load in relation to the value per activity.

Although they are very powerful tools for strategy development, the Eco-pool and profit pool concepts are in general not based on the full lifecycle of a product or service. These concepts are based on the total volume of business sectors. So they are not intended to compare complete lifecycles of PS systems with a reference. This means we cannot compare systems on the basis of a unit function fulfilment, as perceived by the consumer. In addition, the pools are best suited to model a static situation. We miss a perspective on the actual changes that occur due to the introduction of a PS system. A most important aspect is the change in consumer behaviour.

The Eco-pool analysis and the three-step profit pool analysis can be repeated to determine value creation and margin *for unit function fulfilment*, instead of the pool based on the estimate of total market size. Therefore, we will introduce *'LCA-based pool tools'* slightly modified to the profit pool and the Eco pool we presented before. This will be done by:

a) shifting to an analysis of the full lifecycle of the products and the services in the PS and reference system,
b) comparing the PS system with a reference on the basis of a functional unit.

The aim of the LCA-based pool analysis is threefold:

1. Analysis of the economic effects: does the PS system create more value per unit of functionality?
2. Analysis of the environmental effect: does the PS system create more environmental load per unit of functionality? This is the typical field of an LCA.
3. Analysis of the ratio of economic value creation and environmental load. This ratio elucidates whether the introduction of the PS system does contribute to unlinking environmental load and economic growth.

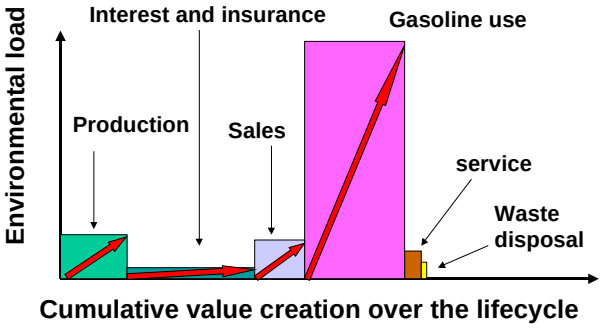
LCA-based Eco-pool

The selection of the activities in the pool is determined by the functional unit under study. Basically all products and processes in this functional unit, taken from cradle to grave are to be included in the pool. Sometimes, it is useful to group these into a limited number of larger steps for practical purposes.

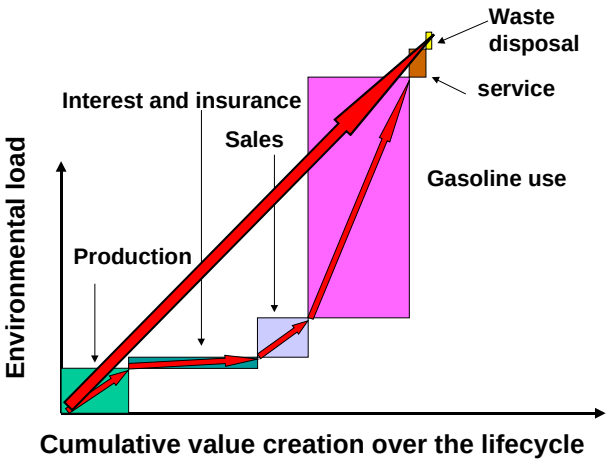
3.5. Analysing the unlinking effect with the E2 vector

We have developed a new tool, the E2 (Economy-Environment) vector, by slightly changing the LCA-based Eco-pool graph. The E2 vector can be used to assess the unlinking of economic value and environmental load, as described in chapter 2.

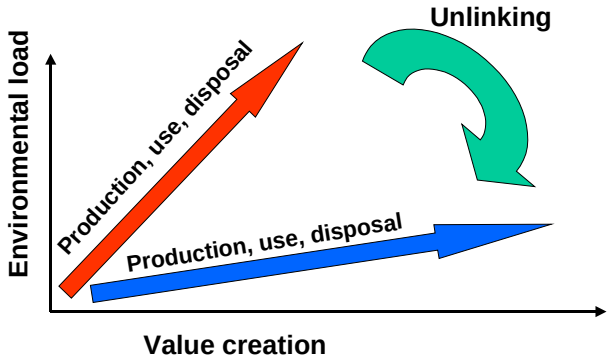
In the Eco-pool concept we plotted the cumulative value that was created against environmental load. For the E2-vector, we plot cumulative value against cumulative environmental load. The result of these changes can be seen in next figure. The blocks form a slope that can be characterised with a vector, which connects the origin with the top right-hand corner of the last block.



These vectors can be combined to generate the overall vector.



A system with a vector that is less steep then the reference can contribute to unlinking, as the ratio between environmental load and value is better. This unlinking is shown in next figure.

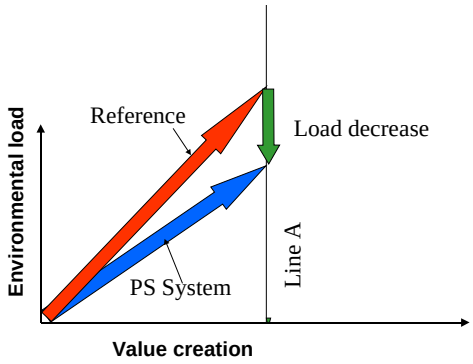


Interpreting the E2 vector

The E2 vector is a very powerful instrument to study the effects of the introduction of new PS systems. Let us analyse a few hypothetical cases in order to demonstrate the power and the surprising new insights the instrument gives. In each case we have plotted the vector of a reference system as a red arrow, while a blue arrow represents the system under study:

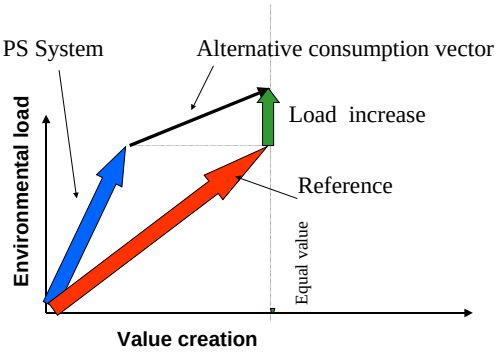
Situation A: Lower environmental load at (almost) equal value

If the value remains constant, while the environmental load decreases, we can be sure that the system has a positive effect on unlinking. The consumer is spending an equal amount of money for the requested function fulfilment in both situations. As there is no financial difference to the consumer, it may be assumed will that there will be no changes in other consumption habits as result of the transfer to the new system.



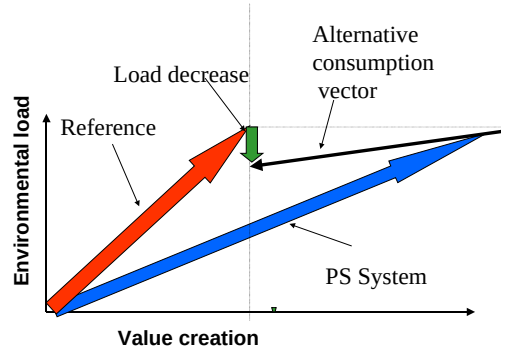
Situation B: (Almost) equal environmental load, at lower value.

In this situation, we will see that consumers save money, while the environmental load remains constant. In a market economy, the money saved will be spent for other purposes. In next figure we have plotted this "alternative" consumption vector. (As a first estimate, this vector could be chosen to have the average E2-angle of day-to-day consumer behaviour (see text box ‘alternative consumption vector’).
The picture clearly shows that in this case the total environmental load will increase. This representation clearly shows the working of the rebound effect. Money saved because of cost reduction will be spent on alternative consumption. Later we shall discuss ways to address the effect of alternative consumption.



Situation C: Increased value at (almost) equal environmental load

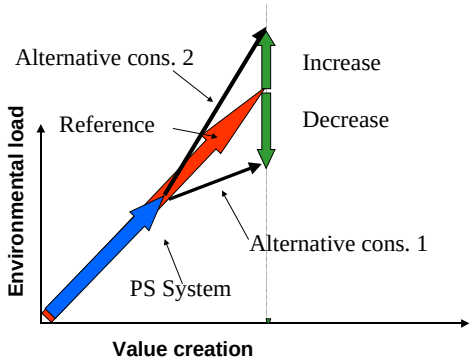
In this situation where consumers are prepared to pay extra for the new system, they will have less to spend on other consumption. This means that the 'alternative consumption' vector has an opposite direction. The net effect is that, even as the environmental load for the system itself remains constant, the overall environmental effect is positive as result of the reduced consumption. Of course a consumer will only be prepared to make the extra payment when he sees clear benefits (e.g. PS-systems that add quality or comfort).



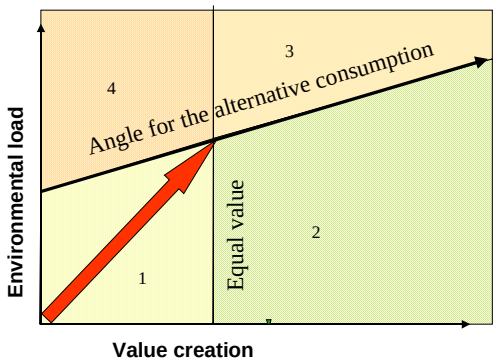
Situation D: both the value and environmental load are decreased in (more or less) the same proportion; the E2-angle remains same.

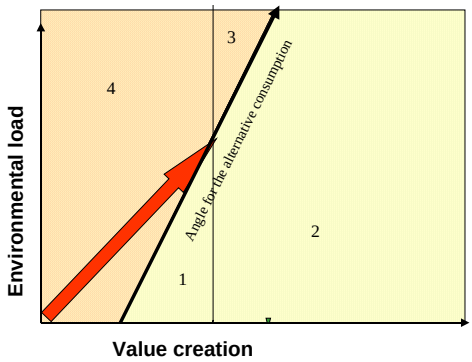
This fourth situation is quite common in the industrialised Western economies: products and services are both more efficient and cheaper at the same time. Huge environmental gain can often found in Ecodesign projects. This is the typical win-win situation. Thus, the new system may be expected to gain market share rapidly. If you look at the new system in isolation, it proves to be beneficial for the environment.

In such a situation we cannot see if there is an overall sustainability gain for society. This is determined by the angle of the additional alternative consumption vector in the new situation. If the alternative consumption is less steep than the E2-vector of the reference system, we assume the overall environmental effect is positive, as is shown in next figure. If the alternative consumption vector is steeper, we will see an overall increase of the environmental load.



With these four examples we can define a more general interpretation of the E2 vector. In next figures we have plotted both the vector for the reference system and the vector for the alternative consumption. The latter vector is plotted through the tip of the vector for the reference system.





If we now plot the vector of the PS system in this picture, we can see that:

- All vectors ending in area 1 or 2 will have a positive effect on the total environmental load created in society. All vectors in area 1 will have a lower value, but the alternative consumption will not create a higher environmental load than the reference. All vectors in area 2 will have a higher value, therefore displacing some of the alternative consumption.
- All vectors ending in area 3 or 4 will have a negative effect on the total environmental load generated by society.

All arrows of systems that end below the "alternative" consumption line have a positive total environmental effect. All vectors ending above this line will have a negative total environmental effect. This rule holds for both situations plotted here.

This relation can also be expressed mathematically with

$$G = L_R - L_S - \frac{\tan AC}{V_R - V_S}$$

Where:

G	Environmental gain at equal value of the reference system
LR	Environmental Load of the reference system
LS	Environmental Load of the system under study
tan AC	Tangent of the Alternative Consumption vector
VR	Value of the reference system
VS	Value of the system under study

A surprising conclusion of this picture is that some PS systems that are both cheaper and have a lower environmental load could (indirectly) result into a negative overall effect on the environmental load of the society. Sustainable concepts ask for high perceived value, in combination with low environmental impact.

Alternative consumption vector

The steepness of the alternative consumption vector turns out to be a crucial factor in our analysis. The vector is meant to show the effect of alternative consumption if a consumer gets more or has less money to spend. There are several ways to assess this phenomenon:

1. The average approach: a simple way is to calculate the average environmental load per unit of value. Look at the average behaviour of customers. Although this is a straightforward approach it has a drawback. When people have more or less money to spend they are not going to purchase more or less "average" products. One should expect that the consumer to purchase more or less luxurious goods.

2. The marginal approach: if we want to take into account the marginal changes in consumption patters we try to observe what people really do if they have more or less money to spend. This marginal consumption is not easy to determine. For instance, we should make a difference for:

- *Long term marginal effects*. If a consumer reduces the expenditure cars by changing to a carsharing system, he or she can change long-term consumption patterns; for instance he or she could purchase a bigger house.
- *Short term marginal effects*. A consumer who experiences a cost reduction or a cost increase as a one time benefit or burden will not change its long term consumption pattern. He will not invest in a bigger house, but will for instance go out dining, or go on safari.

Marginal consumer behaviour is probably highly income, age and gender dependent. It is clear that marginal data is fundamentally much better than average data. However it is also clear that it is very difficult to get reliable marginal data. Similar discussions are also occurring in the LCA methodology debate.

In this project we have not been able to come up with reliable figures for average and marginal alternative consumption vector data.

4. Ten examples of PS systems

4.1. How we've selected the cases

Aim

This chapter shows ten examples of Product Service systems. Today, each of them has been introduced (more or less) successful into the market. Our aim has not been to redesign or investigate each example in-depth. The chapter just aims to describe a variety that can be found in practice. Redesigning PS systems looks like an exiting next step to us.

We have chosen not just to give examples of lending, pooling, sharing and hiring. We feel that in the long term, any PS system deserves to be investigated on environmental potential.

Second goal of the chapter is to build practical experience in the application of the 4-axes model and the profit- and Eco-pool concepts. Each case description contains a panel assessment. In complex judging and decision making processes, panel assessments are not uncommon. This was confirmed in several of our interviews. As we explained before, any panel assessment is essentially subjective. Results therefore are our results. The panel assessments are to be regarded as a first trial assessment in this new matter. In some cases, they had to be made lacking in-depth knowledge of the market situation.

Case selection process: our criteria

First a list of 140 PS systems has been gathered. Ten PS systems have been selected from this list using the following criteria:

- cases must be understood by the general public as well as professionals,
- cases must be put into practise or at least be in a pilot stage,
- both product and service component must be economically interesting for the providing company,
- cases should have macro-economic potential,
- the ecological potential is unknown or seems promising,
- as a set, the cases must offer a variety of products, market segments, applications and characteristics of the provider (product provider, service provider or a mixture).

For the latter we've used our PS-categorisation described in chapter 2.

Cases selection

The following ten subjects have been selected:

- Odin subscription to eco-vegetables for consumers
- Gispen hotel-office for governmental bodies
- Stybenex polystyrene insulation lay-out plan, prediction model and take-back service
- Libertel GSM-telephone subscription with free device
- Douwe Egberts professional coffee systems
- Electrolux laundrette products and services
- Carsharing
- Timesharing of luxury yachts
- Postbank Chipper card payment systems
- Koppert pest-free guarantee service.

4.2. Categories of cases

Categorising the markets

Five cases are focussed on professional markets: Gispen, Stybenex, Electrolux, Koppert, Douwe Egberts.
The consumer market cases are: Odin, Libertel, Carsharing, Postbank, Luxury yachts.

Categorising the PS-ratio

In chapter 2 of this report we have described a simple categorisation scheme for PS systems, according to the weight that product components have for the economic impact compared to the service components. The category of each case is given below, and illustrates that a wide selection was made.

Product with additional service (Ps)
- Service provided during product distribution: Odin subscription to eco-vegetables
- Service provided during product specification and retribution: Stybenex insulation layout plan, prediction model and take-back service
- Service provided during product specification, sale and use: Gispen hotel-office.

Service with additional product (Sp)
- Product offered by service provider, in order to lower the entrance threshold: Libertel GSM-telephone subscription.

Product and service equally important in fulfilling a function (PS)
- Entire client satisfaction by providing products, auxiliaries, ingredients and services: Douwe Egberts Coffee Systems International, and full service Electrolux laundrette
- Part-time use, part-time ownership of products: Carsharing
- Part-time use, shared ownership of products: Timesharing of luxury yachts
- Functional use, non-ownership of products: Electrolux laundrette (self-service).

System change (SC)
- From coins to electronic purse: Postbank Chipper card
- from selling pesticides to selling pest-free guarantee: Koppert.

4.3. How we've worked

Source of information

For each case we have interviewed the responsible manager or representative of the PS system provider. The interviews had been pre-structured and detailed enquiry forms were drafted as supportive tools for the interviews.

Panel assessment

For each case we have applied the panel assessment method. After the interviews took place, we have formed an internal expert group. With this group we tried to come to consensus about scores on the four axes. We have found that after having examined all cases it's wise to compare the panel assessment outcome between the cases.
Unless explicitly stated otherwise, the scope of the assessment is as follows:
- company level for the economic, strategy and identity and customer acceptance axes

- life cycle level for the environmental axis

In-depth analysis

For three examples we've detailed the economy-ecology-axis quantitatively. The results can be found in the next chapter.

Description of the cases

The description of the cases in this chapter will follow a fixed format, including:

1. Introduction with short background information
2. Function of the Product Service system
3. Reference situation and functional unit
4. Panel assessment on 4-axes model, including environmental effects, economic effects, strategy and identity and customer acceptance
5. Epilogue: what can be learned from this PS system?

4.4. Organic food by subscription: ODIN

Odin Holland supplies organically grown food to consumers by subscription. Once a week the consumer receives a paper bag with assorted vegetables and accompanying recipes from a store in the neighbourhood. Often the collection point is an organic food store. The traditional greengrocers and supermarkets offering this service is growing quite fast.

The bag serves the need of two persons for about four days, leaving freedom to the consumer to buy other foods.

Odin only sell organically grown vegetables with the "EKO" label certified by SKAL. Further Odin supply regionally grown food, aiming to minimise environmental impact caused by transport. For variation purposes a small amount of food is imported, especially in wintertime.

In the Netherlands three distribution-centres have been realised. The supply is based on fixed price contracts between Odin and farmers, without intermediates such as auctions or wholesalers. This enables planning in advance and distribution advantages. Contracts with consumers are the firm basis to offer this advantage.

To be able to offer enough variation, Odin uses planned cultivation of vegetables. Therefore, Odin's people are always in close contact with their farmers. Odin can be regarded as a "chain manager". This extends to giving agricultural and horticultural advice to farmers by Odin experts.

Functions of the vegetable subscription

The primary function is to supply food with low environmental impact. Odin has identified several supplementary functions for their subscription service:

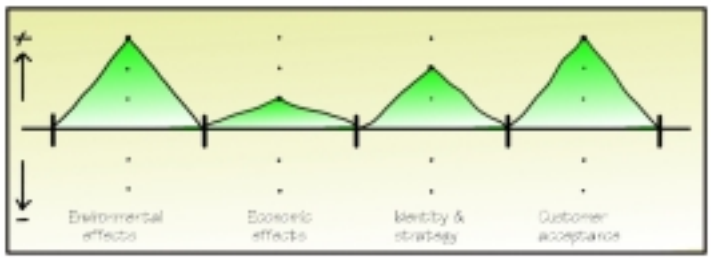
- *Financial*: by guaranteeing a fixed price for their produce, Odin enables farmers to convert from traditional farming to organic or bio-dynamical farming. Additionally, Odin consults with agricultural and horticultural advice. For the consumer, the price of the subscription is lower than buying vegetables separately in an organic food store. Due to the introduction of Odin's service the organic food stores experienced 15% additional growth due to increased shop traffic, mainly by new customers. Odin itself has experienced revenue growth of 50% in 1998 only.
- *Proper amounts*: the consumer gets a fixed amount of food, enough to feed 2 or 4 persons for 4 days, for a fixed price. Currently the price is about 5 Euro (10 Dfl.) for a weekly bag for 2-persons. A 4 person's bag is priced 8 Euro. Odin tries to put as much variation as possible in the composition of the bag; in wintertime some food from Italy is imported to assure variation.
- *Surprise effect*: some of the subscription holders experience a surprise effect when they get their bag with vegetables for the next week. The bag includes recipes that encourage cooking with less known vegetables such as parsnips or squash, offering new tastes. Each week Odin includes about 5 to 7 original recipes especially for the vegetables in the bag.
- *Availability*: the subscription service improves the availability of ecologically grown food for the customers. Consumers don't have to search special organic shops that are found only in urban areas. Market share of ecologically grown food increases.
- *Known history of produce*: Names and addresses of the farmers are communicated to the customers, who can visit a farmer in their neighbourhood

just for curiosity reasons. So, they know the origin of the vegetables in the bag and that the product has been grown ecologically or bio-dynamically.
- *Freshness*: Odin claim their vegetables to be fresher than those sold in supermarkets, since they are delivered directly to them. In addition the vegetables are organic season products that are mostly regionally grown.

Reference situation

As reference situation, we selected the buying of non-organic vegetables from a supermarket or green grocer in The Netherlands (as only few supermarkets offer ecologically grown vegetables).
In contradiction to Odin's bag, the consumer has a free choice of vegetables. The way these vegetables are grown or handled is not always clear. Most of the food originates from The Netherlands, although during winter the amounts of food imported increase. Imports come from all over the world, such as southern Europe, Africa or South America.

Assessment by the panel



Environmental analysis
If the subscription service is compared with traditional purchase of vegetables, the following significant environmental gains of the subscription service are identified (PRé, 1998).

No use of pesticides
Organic farming tries to avoid the use of pesticides. In case of severe pests natural pesticides are allowed. Traditional farming in Holland uses 30 to 220 mg pesticides per kg produce, for import vegetables this is claimed to be at least a factor 7 higher.

No use of artificial fertilisers
Traditional farming has high phosphor (P) and nitrogen (N) losses to surface and ground water. The Dutch government has set limits to the losses that will be stricter in the future. Due to the use of manure rather than fertilisers, organic farmers can already meet the requirements for 2000, with N and P losses respectively 36 and 22% lower than traditional farming. However on a kilogram basis the differences would not be that significant due to the lower production in organic farming.

Less transport
Especially in wintertime the differences are significant as traditional supermarkets obtain part of their vegetables from countries like Spain, Italy, Morocco, Egypt and the Sudan. Especially from Egypt and the Sudan produce is flown in. On average Odin has 30% less transport and 60% less transport energy use than traditional vegetables in wintertime. In summer time the difference is small.

Less packaging
The subscription service uses 4 times less transport and product packaging than vegetables bought in a supermarket. This mainly due to the reduced use of one way

packaging for imported vegetables. Nearly all other vegetables are transported in reusable crates. For the subscription service the paper bag is both a product packaging and shopping bag this is used to transport the vegetables home.

Economic analysis

Odin offers a product with high emotional value, which is interesting from an economic point of view. Analysis of the margins for food obtained from the supermarket, organic food stores and the subscription service reveals that both the farmer and the shop gain from the subscription service. As “chain manager” Odin can guarantee sound margins for food store and farmer. The food is supplied in such a way that ‘losses’ (mostly unsold food) are kept to a minimum. Odin takes the financial consequences of these losses.

Approximate margin in % (based on price incl. VAT)	Supermarket	Organic food store	Subscription Service
Farmer	25	40	45
Wholesale/Odin	45	35	30
Shop (incl. food losses)	30	25	25 (no food loss)

Identity

The ODIN organisation has started practically from scratch. It all started by a small group of highly motivated people trying to improve market acceptance for eco-food. Identity can be recognised as major driving force. The company’s identity is closely connected to the product.

Consumer acceptance

Eco-food is still a niche market. For the organic food stores the subscription service was a success. Mostly, it is a new customer for the store making use of the Odin service. After 6 years there are 20,000 subscription holders at 440 collection points for the Odin bag. This number is still growing. Questionnaires that are regularly sent with the bags (90% response) and telephone feedback at Odin’s information line learn that consumers are highly satisfied and very much involved. Odin's customers are genuinely concerned about the environment and personal health and they feel this service is a contribution to a better world (and a clean consumer conscience).

Epilogue

Key of the success of the vegetable subscription lies in the fact that Odin manages the whole chain from growing, distribution and packing up to retail efficiently. Odin offers products with a high emotional value and has distribution advantage through fixed contracts with suppliers and clients.

4.5. Hotel Office of Gispen in co-operation with Dutch State Buildings Services

Many of the buildings of the Dutch Ministries house temporary project groups that work as flexible and rather independent units. Often the moment of installation of these groups is rather unpredictable (e.g. as result of certain political developments). Thus, ministries need to reserve room for their eventual housing. The Dutch State Buildings Services (Rijksgebouwendienst, Rgd) has initiated an experiment to house these temporary groups more efficiently in a separate building: the Hotel Office. Interior and communication systems are adapted to the temporary needs of the groups. If these change, the Hotel Office will adopt its facilities, interior and systems as well. One doesn't only hire space in the Hotel Office, one hires the right to use all means available: (cordless) telephones, desks, lounge chairs, informal meeting spaces, secretaries, DTP assistance, and so on.

In order to get this all done, the Dutch State Buildings Services has started an alliance with the department of facility management of the Ministry of VROM, Gispen office furniture, ESD networks and Groeneveld Sign Systems. Here we focus on Gispen's role (Venneman, 1998).

Gispen is a well-known Dutch producer of modern style furniture. Today, Gispen focuses on producing office furniture. During the design phase of the building Gispen provided a consulting service as a working process specialist. Gispen has worked out a new furniture concept. Furniture is not sold, but leased.

The concept
Initially, Gispen offers an expert consulting service specifying the furniture concept for a new client. Next, the selected set of chairs, tables, cabinets and mobile walls are delivered and are leased by the client. Subsequently, for the period of use of the furniture configuration changes and moving is assisted by Gispen. As soon as a new group moves into the building new furniture functions will be needed and the process repeats itself.

Function of the hotel office

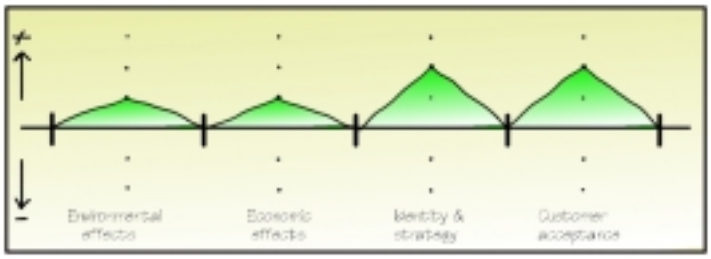
The primary function of the Hotel Office is to house temporary project groups. For the State Buildings Services, the intention is to reduce the amount of net dwelling space needed and provide means that are perfectly adapted to the specific working processes of temporary project groups. For Gispen the Hotel Office is a means of getting in contact with the client earlier in their decision making process and to add value by providing service.

Traditionally, people from the ministry select and buy standard furniture themselves, make reservations in the number of officer’s working places to cover unforeseeable claims to house project groups. The expected result is that rooms, tables and chairs are not effectively used.

Reference situation

As a reference the housing and facilitating of 10,000 public servants, including their temporary groups could be taken.

Assessment by the panel



Environment
For administrative organisations such as ministries, the environmental bottleneck is not pencils, erasers or floppy disks. If one analyses the actual loads, it is merely the emissions from energy used inside the building (electricity and gas needed for cooling, heating and lighting), and emissions from transport (in case the tasks demand mobility).
By flexible space hiring instead of maximum space reservation the average occupancy rate of office buildings may rise. The Hotel Office has reached an occupancy rate of over 90%. That is extremely high for an administrative building. Housing concepts capable of raising the occupancy rate will bring environmental improvement.

Leasing and exchanging furniture means furniture is not constantly in use. For a single building, these quantities probably equal the amount of spare furniture needed in the traditional situation. If several buildings share a pool of furniture, the amount of tables, chairs, etc, not in use would be minimised.

The assessment panel considers that this PS system scores slightly positive (+1) on the environmental axis. Main arguments are:
- A more efficient use of both furniture and office building.
- Advantages of building a pool of furniture: only needed furniture is installed. If the next client has different needs furniture will return to the pool and is refurbished when necessary.
- Partial consumption of these environmental benefits of the newly created furnishing services and additional logistics.

Economics
Reducing overall office space saves money. On the other hand, leasing and services have to be paid extra. In this case, sound exploitation (break even) is reached at occupancy rates of at least 65%. With an actual average rate of 90%, the Hotel Office meets this financial criterion with ease. The Dutch State Buildings Services has decided to continue after this experiment.

At first, making money by providing services was not the first goal of Gispen. In fact, their aim was to increase customer value by individual support to clients and building partnership relations in an early stage of the decision making process. This is expected to offer long term strategic advances, rather than short-term income.

Economic axis: slightly positive (+1):
- Sales of furniture by Gispen will be put under pressure by the competing concept.
- Revenues of providing furnishing services and leasing contracts will steadily grow.

Strategy and identity
The Hotel Office enables Gispen to change the nature of its contacts. From the traditional role of vendor of furniture at the moment a new building is ready, to the role of facility manager, decision-maker and office-architect from the moment that the first plans for a building concept are being discussed. Gispen thus upgraded from supplier to partner. This implied a change from innovative furniture maker to fully equipped interior and facility management expert. Additionally the Hotel Office has lead to new options for strategic alliances.

This is quite a big step for the furniture producer. It is understandable that initially scepticism could be heard within parts of the Gispen organisation. Moreover, the organisational structure needed a change. If someone is used to get cash on the nail, he will regard an advice period before purchase as dangerous and might react impatiently.
New disciplines, new skills and new knowledge had to be built up and spread within the company. It has taken Gispen some years to change from furniture maker to a recognised partner in the market. Many fellow companies have not (yet) followed the moves Gispen made. Gispen is playing the game with new rules, which they decline or not appreciate at their real value. Time will learn who holds best cards.

Strategy and identity axis: positive (+2)
- Gispen has set a goal to shift from production and sales, to providing a customised office furnishing service. The aim is to realise the best working environment for the client (including needs, aspects of organisation culture, budget, etc).
- For this, an organisational change and internal support is needed. The service-oriented strategy will partly supersede the old product oriented strategy. The process can be qualified as merely ‘bottom-up’, and seems well on schedule. Still, it needs time and real arguments (and market response!) to convince the director's board that the new strategy offers business advantage in the end.

Customer acceptance
The customer himself (the State Buildings Services) has initiated the innovative concept, so customer acceptance has been guaranteed. In the world of facility management, experiments with flexible interiors and in specific cases, with the absence of dedicated working places are well known. A (upper and middle) part of the market is ready for change. This supports experiments in the field of flexible working space, leasing, renting, and distant-working.

Consumers have to change their purchase system. In the past, a purchase decision was simple and included the furniture only. In the future the scope will be broadened to include all aspects of the office’s working space, since that’s where the real advantages are. They have to involve different experts from start.
The strategy is not without risks: Gispen has found the outcome of services is difficult to protect. Once an interior plan is drawn, clients could shop for furniture from price sellers. ‘All-in’ contracts or declarations of intent can be a solution.

Client acceptance axis: positive (+2)
- For the client investment costs decrease, while operational costs increase.
- Client loyalty will increase because of regular contacts with the maintenance and furniture experts of Gispen. RSI (repetitive strain injury) and low back pains have become serious problems in administrative organisations. Their financial impact has opened the eyes of organisations for the importance of professionally furnished working places.

Epilogue

Gispen is a good example of changing from supplying goods to PS systems. Though the company is well aware of Ecodesign practice, environment has not been leading in this case. Building customer relations was the key issue.
The environmental potential of the Hotel Office concept is clear. Acceptance depends on the willingness of ministries to co-operate towards more flexible office planning.

The unfolding of the strategic decision of Gispen will take years. It's yet unclear where the changes will ends in the long term. Coming from a production organisation, Gispen might finally transform into a service and consultants organisation.

4.6. Stybenex layout plan and return system for EPS

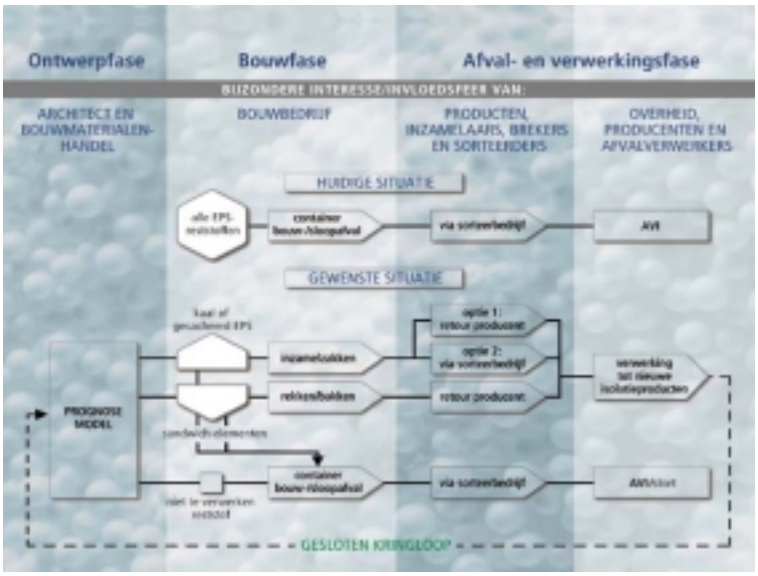
Stybenex is the Association of Manufacturers of EPS-construction products, formed in 1976. Six manufacturers work together in Stybenex to promote and improve to use of expanded polystyrene (EPS). For example, Stybenex publishes communal technical advice and supports the members to improve the environmental performance of EPS throughout the life cycle (van Zuilekom, 1998).

EPS has two main applications: 20% is used as packaging material, 80% is used as construction and insulating material. The primary function then is the insulation of roofs, floors or walls. In building applications, producers deliver insulation materials in different forms so the product has also a more constructive function. Insulation products are foam EPS, sandwich elements and laminated EPS. In 1996, all producers together sold 40,000 ton EPS on the Dutch market. When using EPS building elements, waste arises due to the size of the EPS elements and holes that are made for windows, exhaust pipes, electricity pipes etc. The waste is about 400 ton annually.

Functions of the Product Service system

EPS is easy to recycle so all producers recycle production waste on site. Next, several producers have return systems for their materials[7]. A 1993 LCA compared EPS with other insulation materials. From this study, it was concluded that several possibilities exist to improve the environmental performance. Producers introduced layout plans and started to deliver increasingly custom-made. According to Stybenex, savings up to 5% can be reached in this way.

In 1997, Stybenex carried out a study to a common return system for EPS from building applications (Stybenex, 1997). This in-depth study was part of the national reuse of waste research program (NOH) and partly financed by Novem/RIVM[8]. In this study, several logistically feasible return systems were described. Considering ecological, economic and logistic aspects, two routes turn out to be feasible. In one route EPS producers take the leftovers when they return from delivery. In a second route, specialised waste separating companies store EPS. After acceptance at the producer's gate, EPS is shredded and re-used in building materials. For the producers it is important to guard the quality of the secondary materials. Since these materials are used in certified products, quality of the final construction product should be high and constant. Due to this, the maximum amount of secondary material is about 5%[9].



In 1998, Stybenex carried out a pilot study together with a few large building contractors and wholesalers of building materials to optimise the return system. The contractors were approached by means of

[7] In addition, a national return system for EPS packaging materials and Garden Trays exists.
[8] In the case no financial support would be given, a more transient study would have been carried out.
[9] If the take-back service is fully operational, this can cause a surplus of secondary EPS. This means, other applications are to be found.

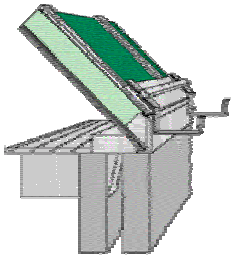
the existing contacts. In the pilot, most attention was paid to separation on the building sites. Only the route, in which producers take back leftovers themselves, is used.
In the future when a take-back service is fully operational, the role of Stybenex itself is still undefined. Most probably, Stybenex will carry out communication towards other parties.

The central user in the system is the building contractor. He is responsible both for the purchases of materials, and the building process, as well as the waste management at the building site. He receives EPS directly from the producer on-site. In the preceding study, a so-called prediction model was developed. With this model, the building contractor together with the architect can forecast the amount and moment EPS leftovers will be released. EPS is collected in special plastic bags for foam and metal racks for laminated EPS and sandwich elements.

Since the primary function of EPS is insulation, the PS system is focused on the installation phase of the product. Services (layout plan, prediction model, and take-back) are added to the product, so in this survey we consider this PS system as a Ps.

Reference situation

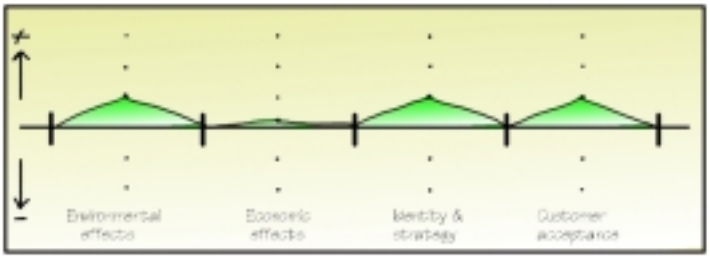
In the reference situation roofs are insulated, without using a layout plan or take-back service. Waste is removed together with other building wastes by a specialised waste remover, and taken to a waste incinerator[10].



For case analysis insulation and building of a roof is considered, where sandwich elements EPS/chipboard are used. One such roof element is shown in the illustration. It is considered that in the reference situation no layout plan is used. The amount of waste is 10%, due to dormers, cut-offs and exhaust pipes. In the PS system situation the amount of waste is 5% and this waste is returned to the producer.

In a normal building project several kinds of EPS are used. An average project uses 65 m2 roofing, 50 m2 walls and 50 m2 flooring having an average thickness of 9 cm. The total costs for this is about € 2300, having a 2% margin for the producer. The average amount of **all** EPS waste is 1%[11].

Panel assessment



Environmental
Stybenex presumes that the highest environmental gain of the PS system is the waste prevention and reduced logistics due to the custom-made delivery and the layout

[10] This situation did not exist in the past, when building waste was partly dumped and partly burned. Due to a Dutch regulation from 1997, it is no longed allowed to dump high caloric wastes like EPS.
[11] This low amount is mainly caused by delivery on specification, and the fact that spare parts of foam EPS are used to fill holes etc within the construction.

plan. The take-back service is only beneficial if extra transport of leftovers is minimised.
The researcher's panel thinks the system scores slightly positive (+1) on the environmental axis:
- the layout-plan will decrease sawing residues
- effects of collection and recycling EPS wastes for recycling are estimated to be negligible (in comparison to transporting a mixture of combustible residues to a mixed waste incinerator for energy recovery).

Economics
Since this PS system is still in a pilot phase, remarks about its economy should be made with care. However, some producers already offer partial individual systems. As said above, the chosen route also turns out to be the most promising in financial sense. Due to the PS system the building contractor saves waste management costs, purchasing costs and an environmental friendly image. The saving on waste management will be more important in the future since incineration costs will be increasingly based on volume instead of weight.

For EPS producers a national return system is cheaper than several individual systems. It will save start-up costs like research and promotion. The benefits of avoided costs of virgin materials are supposed to balance costs made for extra handling and machinery.
Producing layout plans is a service with commercial value. It is applied as a marketing tool. Today, no additional price is asked. For clean residual materials, investments needed for feeding into the existing production lines are small and raw material expenses are saved.

The economic score for the producer of the PS system by the panel is neutral (0)[12]:
- Layout plans improve the efficiency of the application of insulation materials thus reducing both sale volume and redundant volume to take back.
- Transport costs for the producers will increase marginally, as trucks that deliver can take-back residues of this (or a nearby) building-site.
- In general, the added service does not seem to increase the price of the EPS insulation.

Strategy and identity
During the last decade the EPS producers have worked hard in order to improve their environmental image. Architects are sensitive to this image. LCA-studies, process improvements, and other activities have indeed resulted in an image improvement. From this history it's logical to make the next steps:
1. The service to provide layout plans builds customer loyalty and positively differentiates EPS producers from suppliers of competing products.
2. Product responsibility is a key factor to offering return systems. Stybenex aims to start a communal project, which is profitable for all member EPS producers and will give them a strategic advantage to other insulation and building materials.

The researcher's panel scores the PS system slightly positive (+1) on strategy and identity:
- The environmental debate has been crucial for this PS system. The sector successfully participates in environmental debates and LCA projects. The former defensive strategy has transformed into a leading environmental strategy.

[12] The economic assessment is expected to give a slightly positive score when the life cycle perspective is chosen. The customer may benefit most from the improved system. The system improves the efficiency of the application of insulation materials and thus reduces costs for the building company.

- The PS system doubles the number of client contacts.
- Transportation is already a well-known core activity.

Client acceptance
The PS system is a new activity for building contractors. The most important issue for them is the return system, including the separation of EPS from building waste. Though not difficult, it demands a change of attitude. Since several separating systems already exist, two scenarios are foreseen: either separation of EPS is accepted very easily or ‘separation tiredness’ will arise.
Overall, the researcher’s panel considers the client acceptance slightly positive (+1).

Epilogue

A national PS system should include all major producers. These kinds of actions contribute to the competitive positioning of the product. In the insulation industry product many quality aspects have become comparable, so service becomes a selling point. Providing tailor-made solutions is distinguishing. The customisation has environmental potential. This is due to the fact that the services added result into more efficient use of the product.

4.7. The mobile phone set by Libertel offers freedom

Currently the market for mobile phone systems in The Netherlands is rapidly growing. Brand names are well known, but consumers do not have a brand preference yet. The geographical network coverage of the Libertel GSM network is over 98% and it offers enhanced full rate, the best quality of sound. This is not regarded as the only USP distinctive anymore; besides network quality, it is also the service and costs that count in the eyes of the consumer.
Costs are the main drawback for private end-users to subscribe. The price of GSM hardware blocks a fast market penetration. Therefore sales organisations of GSM networks like Libertel offer a GSM device for free (or at reduced price) to any new client. The free GSM device is an example of a service provider who offers a hardware product, in order to serve the client better. The device itself could be of any brand: Sony, Ericsson, Philips, Nokia, Siemens and Motorola.
The Libertel Groep is a young (since 29 September 1995) and innovative player in The Netherlands. This mobile specialist owns a GSM network (the hardware out in the country). Capacity on that network is sold to clients by the Libertel sales & services organisation. Libertel has been founded by Vodafone Group (UK), ING Groep (NL), LIOF Limburg, Vendex, Internatio Müller and Macintosh Retail Group. Nowadays shareholders are Vodafone Group UK (70%) and ING Groep (30%).

Function of the GSM system

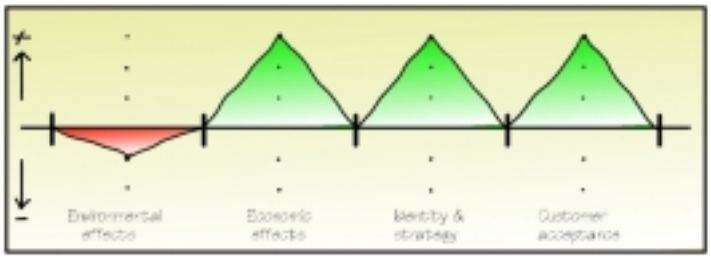
For a client, the primary function of a mobile phone is to make and receive telephone calls at any time and any place. So the main function is combining mobility and distant speech.
As the market grows, technological innovation continues and services are expanded, additional functions are integrated rapidly. The current system provides features like car sets, sending written messages, personal phonebook, personal organiser, watch, vibrating function, voice recognition, connect services, and so on.
Primary function
For distant speech, the traditional situation is the corded telephone. Device on the wall, copper wire or glass fibre underground, digital connection stations, operators and satellites in space. Mobility is traditionally served through public telephone booths, telephones in restaurants, gas stations and pubs, pager/buzzers and semaphones.
Secondary functions
For the secondary functions, the options are answering machine, paper agenda, phonebook, letter, fax and email.

Other competing systems for the primary function (speech telecommunication) are:
- cordless home set (a reach of about 300 meters)
- walkie talkie
- the NMT analogue network
- satellite systems
- GSM 900 and GSM 1800 networks
- (coming up) Internet.

Reference situation

With so many features, a standard functional unit becomes quite arbitrary[13]. A valid choice could be:
the ability for 1 million people to call and be called mobile during one year, to send and receive small written messages, to store phonecalls temporarily and to keep up a personal phonebook.

Assessment by the panel



Environment
Currently there are 3 million phone sets in use in The Netherlands. The average product life is about 3 years. Each set has a battery, a battery charger and a voltage adapter. Weights: about 100 gram for the battery, 150 gram for the GSM device, 300 gram for the adapter. Without taking into account spare batteries, car kits and other accessories like cases, this results in an annual waste of about 550,000 kg. A battery is charged each three days. Most of the adapters are continuously connected.
A new organisation has been founded (energy and waste). Libertel has built 1500 antenna stations in The Netherlands (energy, view disturbance and electromagnetic radiation). But there is no copper in the ground. Devices are far more energy efficient, and hardly any GSM user uses a telephone book anymore. Semaphones seem to have become obsolete.

Macro level
If one chooses the macro perspective, the environmental picture gets very complicated. GSM changes behaviour patterns of consumers completely. It offers a large added value as a service organisation and it is used as an additional infrastructure and service system.
GSM makes people more mobile (emissions, more traffic jams), workers more flexible (less traffic jams, less working space needed) and car drivers more productive (productivity and disconnection economy/ecology). It stimulates replacement of desktop computers by laptops (materials and energy).
At last, GSM is not only replacing traditional devices; often it is additional to the existing phonebook, corded telephone, fax, etc.

The panel considers that GSM phones score *slightly negative* (-1) on the environmental axis (with a high level of uncertainty):
- The communication infrastructure is additional to existing infrastructures (1500 to 2000 transmitting stations for each GSM network in The Netherlands).
- Annual waste of 550 tons is additional.
- No copper wiring needed underground.
- Each battery loading system requires stand-by energy.
- The battery waste contains heavy metals.
- Electromagnetic radiation is under suspicion of being harmful for the human body, however no research could ever prove that GSM might have harmful effects on your health.

[13] GSM offers a new functionality and behavioural change. Therefore, it is difficult to select a reference system. For our qualitative analysis, we have chosen the combination of phone booth and semaphone. We realise that GSM offers more features than that.

Economics
The market shows an enormous growth. But market share has a high price. The Libertel distribution shops buy a GSM device for about 160 to 360 €, depending on the model. They 'give them away' additional to a subscription contract. Additionally, for each new subscription the distribution receives up to 225 € from the network operator Libertel and the Libertel Service provider. Each month a client receives a bill. Average fixed amount is about 15-30 €. The calls made and services used are billed on top of the monthly subscription fee (other subscription formulas exist also).
It might be interesting to compute the ratio between economic achievement and ecological impact (E2-vector) of fast growing businesses like mobile phone companies. A booming company like Libertel invests large sums for building up a full-covering network. An investment of 500 million € for just the Dutch GSM network (to be written down in eight years; Telecom magazine June 1997), an annual turnover of 300 million € (Planet Multimedia, 23 April 1998) and of course a double-digit return on shares value in the near future could lead to a conclusion that although to environmental impact is negative at first glance, the E2-ratio probably has a far better score than within the traditional phone companies. In this project we do not have the opportunity to research the details necessary for such computations.

Identity & strategy
One of the shareholders of Libertel is a communication specialist. There is no discrepancy between the organisational strengths and the product requirements. Libertel goes for an innovative image. Emotional aspects have been provided via a donation contract for the World Nature Fund (score +3).

Consumer acceptance
In The Netherlands there is a nearly general acceptance of GSM use. Large groups desire to use it, males more than females. Acceptance in public domains (trains, streets, and shops) seems lower than in other European countries. It is a product with a very high-perceived value.

Mobieliquette
In June 1997, Libertel issued a book named Mobieliquette, in which the etiquette of mobile telephony is described by famous Dutch soccer player and columnist Jan Mulder. On the last page of the book, the Libertel advice is stated: *´call as much as you like, but do not disturb anyone else´*.

Client acceptance axis: highly positive (+3)
- Clients highly appreciate the new functionality of GSM that guarantees maximal mobility and freedom.
- Big business, providers all together sell 80,000 subscriptions per month in The Netherlands.
- However, E/M-risks are taken seriously. New medical results could be a threat for client acceptance.

Epilogue
We are talking about a system change here. Libertel is a service organisation using hardware to provide added value. The system change induces behaviour change, which makes a detailed environmental analysis a hard job. Although we have not been able to work out a detailed environmental accounting here, from an unlinking point of view we estimate Libertel to deliver a far better E2-ratio than traditional phone companies.
GSM does not fit the needs perfectly. The dis-functions are inability to transmit large data files, battery operation, stolen or damaged devices and a sound quality lower than traditional phone system against a higher price. But mobile speech appears to be a value highly priced and worth paying. Offering free GSM devices help consumers with their initial decision. Just like Gispen adding service as a producer in the specification phase of interiors.

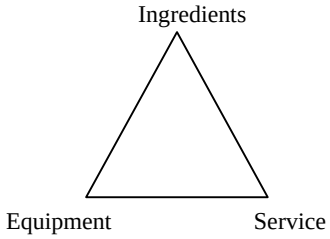
4.8. Douwe Egberts Coffee Systems international BV

Douwe Egberts Coffee Systems international BV (DECS) is a division of Sara Lee/DE. Operating world-wide, DECS is currently successfully supplying coffee systems to over 40 countries. The head office is in Utrecht, including the majority of the R&D staff (DECS, 1998).

DECS develops and offers a range of coffee systems for the out-of-home market. Branded, high quality ingredients (coffee) is the core of the systems approach. The dispensers and servicing are added for securing the supply of top quality for each cup of coffee.

Customer requirements significantly differ from location to location. In the commercial sector (hotels, restaurants, and cafés) demands differ from the industrial (offices, factories) or institutional (hospitals, education) sector. Therefore, DECS offers a wide range of solutions.

The Product Service system



In 1986, Douwe Egberts decided to enlarge their scope of activities from producing and distributing coffee ingredients (beans, sugar, etc), to the development, production, distribution and maintenance of coffee systems according to the triangle concept as shown. Development of the dispensers, cleaning systems, maintenance programs and promotion all became responsibilities for DECS. Also accessories like coffee cups, ashtrays etc and training have been offered to the user. Brand and image have become increasingly important compared to traditional selling points like technical features.

This strategy has had two important purposes:

- To be able to control the quality of the entire coffee making chain. A stimulation for café owners to buy a complete coffee system, is the fact DECS takes care of issues like HACCP. DECS considers HACCP as a trigger or stimulus for their business.
- To offer total solutions for the customer and maximise added value.

HACCP
HACCP (Hazard Analysis Critical Control Points) is a prevention system on safe consuming of food and drinks. The focus of this system is the consumer. A company assesses all processes from growing of raw ingredients to the processing, packing, storage and preparing of food. All processes are assessed and administrated on risks and dangers of biological dangers (fungi, bacteria, yeast and scum), physical dangers (glass, metal particles, wood, etc) and chemical dangers (insecticides, herbicides and pesticides, cleaning agents, natural toxins).

With this Product Service system, DECS aims at *fulfilling needs* rather than selling a product or a separate service. In our methodology this PS system is considered as a product and service equally important in fulfilling a function (code PS).

The strategic decision has had a large impact on the customers and the organisation. Although the user is still responsible for making and serving the coffee, each dispenser is equipped with a system to assure regular cleaning and maintenance.

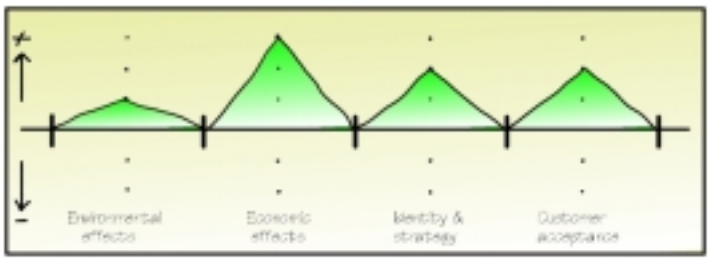
An important feature for nearly all owners is the speed of coffee brewing. As a reminder one should think about the break in a theatre or cinema.

The primary function is to serve coffee in a commercial setting. In a traditional system, a restaurant or café owner buys a coffee maker, coffee and additional ingredients, and repair services from different parties. The equipment is an oversized coffee maker like those used in households. Coffee is made in batches of 10 to 20 cups and kept until served in a glass coffee-pot.
Additional functions are to reach a constant quality, to clean and maintain the equipment, to supply the ingredients and to control safety aspects throughout the chain.

Reference situation

As a functional unit for comparison 100,000 freshly brewed cups of coffee can be defined. The user does the brewing and serving: the tender in a hotel, café or restaurant. In order to be able to sell out coffee he needs al the ingredients next to equipment that works and is clean.

Assessment by the panel



Environment
DECS believes the PS system to have a slightly positive effect on the environment. Hygiene aspects are performing better since just just one party controls the entire chain.

In the panel assessment this PS system has been considered slightly positive too (+1):
- Environmentally the dominant phase is the use and maintenance stage
- The efficiency of the coffee machine is improved. No heating plate is needed.
- No or less surplus coffee will be brewed and thrown away.
- The service and supply visits by DECS reduce the environmental benefits somewhat.

Economics
When introducing a new PS system (new brand or concept) DECS takes a time span of five to ten years. The economic lifetime is very much determined by the hardware and fashion. Since new concepts are to be introduced all over Europe or even world-wide, quite some time is needed to achieve a considerable market position.

DECS launches market concepts once in several years. Each needs a lot of training and human resource management. While some concepts have failed, others are highly successful. This risk is taken into account during investment decision processes.

In most cases the user becomes the owner of the equipment. This strategy is chosen by DECS since owners are considered to be more responsible users. Besides, in the catering industry it is common to use cash money for relatively small investments. If a café owner needs to lend money, a bank is a more obvious way.

For both DECS and the café owner the PS system is considered highly profitable (+3):
- Due to the guaranteed quality, the brand impact and the product line, the consumer price per cup of coffee is higher
- DECS role changes from a producer of ingredients (with a relative low price) into a function fulfiller.

Strategy and identity
DECS have started to develop the PS systems because of market development reasons and a wish to increase turnover. The system approach has turned out to be adequate today, when companies focus on their core business.

The strategic change required an organisational change. DECS have become more internationally oriented and has set up a much larger service organisation. A lot of training has been necessary and a shift has been made from a retailer organisation to a project organisation.

The company's identity has been broadened from ‘DE’ to ‘DECS’. The extension ‘Coffee Systems’ to emphasise the business-to-business focus.

The panel considers that the system approach scores positive (+2) on Strategy:
- The internal motivation has been important for the change.
- Internal acceptance has been high.
- DECS have changed rules of the coffee game.
- Introduction has initiated a differentiated market approach.

Customer acceptance
A majority of the users has accepted the system approach. They spend less time on coffee brewing, thus being able to focus on the core business: taking care of ambience and atmosphere. When the visitors appreciate the ambience, there is willingness to pay more for drinks and food. However, *scrooges* still prefer to keep everything in their own hands.

As a spin-off consumers buy the same brand for home consumption.

In the panel assessment the client acceptance was considered positive (+2):
- Constantly a higher quality of coffee.
- DECS takes care of hygienic issues throughout the chain (HACCP).
- Speed of deliverance a cup of coffee is higher.
- Differentiated market approach is needed; some consumers will not accept the higher price.

Epilogue
DECS’s strategy gives them a higher influence and responsibility of the market. They take care of some of the difficulties of the clients, but charge a price for that.

Outdoor food and drink markets offer big opportunities for PS systems. The turnover of food and drinks consumed is in the Netherlands already higher than the turnover for home consumption. In the near future also the amount of food and drinks consumed outdoor will be higher than home consumption.

4.9. Wascators by Electrolux

Electrolux is one of the world leaders in the market for home appliances (refrigerators, washing machines, ovens, vacuum cleaners, etc), powered devices for gardening and forestry and commercial appliances (products for professional cooking, refrigerators, cleaning and washing). Electrolux has 106,000 employees world-wide, together manufacturing and selling more than 55 million appliances. Annual sales are more than 13 billion Euro.

The Product Service system: planning and running a laundrette

Electrolux washery services are part of Electrolux Professional appliances[14]. Since 1988, they work on upgrading laundrettes in the Netherlands (Van der Linden, 1998).

Very often laundrettes are dingy places in grimy areas. Electrolux now helps initiators to start a new laundrette in attractive areas (in shopping areas), or to upgrade old ones. These laundrettes look more attractive, are equipped with modern machines, and offer extra services like ironing and delivery. Electrolux supply complete solutions for customer's laundry requirements. This approach includes equipment, installation, training, suggested layouts, support on environmental permits, market survey, service, guarantees, and financing.

The initiator becomes the owner of the laundrette and is therefore responsible for the running and the financial risk. He can have a contract with Electrolux for maintenance and repair of the machinery.

Electrolux have its own internal bank for financing laundrette entrepreneurs. This bank can offer more attractive loans than a regular bank. Regular banks do not consider laundrettes as a viable way of business. Since most initiators of laundrettes are newcomers, Electrolux use the lease concept as a sales tool. The number of lease contracts nowadays is about 10% of the laundrettes, but is expected to rise to 20% in five years. This goes also for institutional washing services, e.g. homes for elderly people and disabled.

Laundrettes have a small piece of the complete washing market in the Netherlands. Most of the professional washing is done in washeries or on location, in which Electrolux have a market share of 25%. Most of consumer washing is done at home.

A modern Electrolux laundrette, called a 'Electrolux Wascator', has on average six machines with six-kilogram capacity, one machine for 12 kilogram, three or four tumble-dryers for 14 kilograms. Such a laundrette is sufficient for an area of about 15,000 people. To make a laundrette feasible it would be advisable to have some professional customers (butcher, small hotel) within this area. Equipment for laundrettes is more advanced than washing equipment for household applications. This not only goes for the washing machines, but also for dryers and ironing equipment.

Electrolux washing machines have a capacity varying from 5.5 to 32 kilograms and cost between € 3600 and € 450,00. These machines are constructed in such a way that water use is based on the load of the machine. Due to the fact that in a laundrette several washing machines are installed it is profitable to use a central ion exchanger. By removing calcium and magnesium from the water, less detergent is

[14] Electrolux Professional Appliances is the Dutch name for Electrolux Commercial Appliances

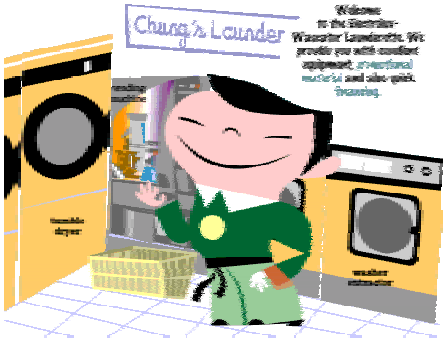
needed. Another feature of laundrettes is the use of an industrial water boiler with a fuel gas valve[15]. In the past, less economic gas dryers were used.

Washing machines for laundrettes have a lifetime of about 30,000 hours; three times higher than washing machine for household applications. Electrolux are willing to take care of discharged machines. Up till now these machines are taken to a scrap yard.

Functions of the Product Service system

The primary of a Wascator is to have one's garments washed and dried. Additional functions are the ironing of clothes, delivering and even offering social contact.

In the case of the Electrolux Wascator, two Product Service systems can be distinguished:



1. Selling professional washing equipment accompanied by a support program for those entrepreneurs who start a new laundrette. This can include a lease contract. The producer helps retailers to improve the performance and image of the products and services.

2. Selling washing equipment to laundrettes for consumer washing. Most laundrettes have full-service as well as self-service possibilities. Most laundrette owners prefer service, since the professional handling reduces total charge time of a washing load.

For this report we have chosen just the washing in the laundrette, because it is expected to have an environmental effect.

We have made the following assumptions:
- The consumer (self-service) and the laundrette staff (full-service) both handle half of the laundry.
- At the laundrette, laundry is washed and dried.
- Washing is done in an average Electrolux Wascator laundrette as described above. In the case a laundrette has five machines of 6.5 kg and one of 12 kg the average load is 7.4 kg.

In a self-service laundrette consumers share the use of washing and drying equipment. This is *functional* use, not owning the product. In the case of full-service laundrettes, it is considered entire client satisfaction by provision of products, auxiliaries, ingredients and services.

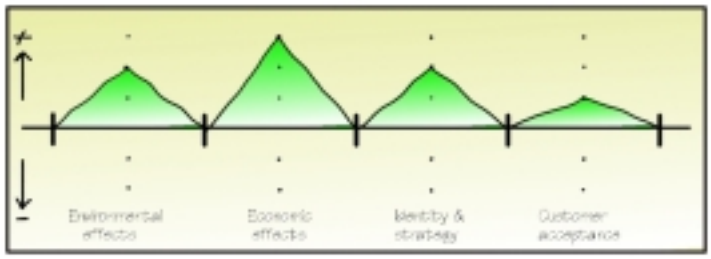
Reference situation

In a traditional system, washing and drying is done at home. Assumptions for home washing are:
- laundry is done in an average home washing machine for 4.5 kg or 5 kg
- 40% of the laundry will be dried in a home tumble dryer (current market penetration of tumble dryers is 53% (EnergieNed, 1998), although thumble-dryers are not used for all laundry. 60% will be air dried

As a comparison between a laundrette and home washing an average washing amount of 1000 kg per year is taken. This means 135 charges at a laundrette or 210 charges (between 4.5 and 5 kg) at home.

[15] When using a fuel gas valve, the exhaust pipe is closed as soon as the input of gas is closed. The hot fuel gas present will fully be used to heat water, instead of disappear to the surroundings.

Assessment by the panel



Environment
The environmental effects of a laundrette are considered slightly positive (+2) by the panel. The washing process, including to use of water, detergent and electricity is much more efficient than home washing. Electrolux presumes the same based on the water efficiency, the central ion exchanger and central heating of water and dryers. On the other hand, laundrettes will give rise to more mobility to the laundrette by the customer or the laundrette owner (in case of a delivery service).

Economics
Succeeding in bringing household work into the economic loop indicates a growing perceived value for clients. The panel regards an increase of washing (and related) services therefore as highly beneficial (+3 on the economic axis). The washing becomes an economic activity, instead of being a household occupation. For Electrolux the turnover for household washing machines decreases; on the other hand lease contract offered to laundrette owners bring revenues. Producers of detergents, water and electricity find their delivery to decrease. For them, the changes are marginal to their total market.

Strategy and identity
The decision to support laundrette entrepreneurs is a strategic one. It is beneficial to the entrepreneurs as well as to Electrolux. For the new comers, the support enables them to start their own business. For Electrolux it is a means of getting revenues from bringing a household activity into the economic network. In addition, a successful laundrette works as a selling window for other Electrolux products.

Consumer acceptance
Laundrette services are addressed to well-specified groups of consumers: students, ‘dinky’s’ (double income, no kids), singles and small businesses having a lot of laundry (hotel, restaurants, etc). Upgrading laundrettes won't bring a massive change in acceptance within these groups. It just helps to (re)gain market share.

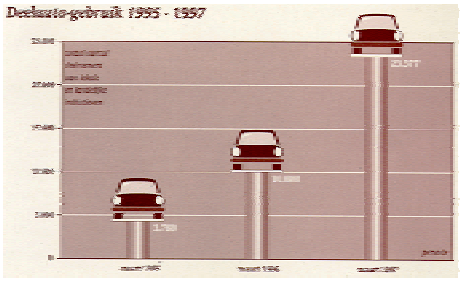
Epilogue

The economic and environmental aspects of this Product Service system will be discussed in detail in Chapter 5.

For Electrolux the Wascator is a dominantly strategic PS service. Both environmental and economic affects are regarded as promising by the panel. The market opportunities of laundrettes are household activities that are increasingly professionalised. In this context we can refer to custom made curtains and boarding out cleaning, children parties, baby-sitting and walk-a-dog (professional services for taking out one's dog).

4.10. Carsharing

In Europe most cars are only used to drive 3 to 5% of their life span. They stand still for about 23 hours a day (Muheim, 1996). Already in the 1940s, experiments were carried out with sharing systems like Sefage (Zurich), coin-cars, and experiments in Montpellier and San Francisco. Due to the demand-oriented and market-proof mobility strategies, car sharing started a new life during the 1980s. Arguments for participants in these systems are lack of parking place, ecological motives, and flexibility in mobility. The first successful European initiatives started in Switzerland.



In cars haring, a group of participants uses a pool of cars. This pool can be as small as one car in the case of a private initiative. In commercial situations, the participants pay a subscription and a fee for the time and/or the distance driven. In the Netherlands, many carsharing systems exist, which together had 23,000 participants in June 1997. Over 500 parking places for shared cars exist in the Netherlands (Mentink, 1998).

Commercial carsharing is offered by traditional car rental companies as well as new businesses and within companies (KLM's Wings-and-Wheels as an internal carsharing system, ANWB has a fleet of cars for internal and private use). One of the best known new businesses in this field is Greenwheels who offer carsharing in the four biggest cities of the Netherlands: Amsterdam, The Hague, Rotterdam and Utrecht. The motives for the entrepreneurs are care for the environment, offering a solution for parking problems as well as expansion of turnover.

The Dutch government stimulates carsharing. Local authorities consider carsharing as one possible solution for parking problems in densely populated areas. A normal car takes an average of more than 3 parking places, which is an area consuming phenomenon. In Amsterdam however, one parking place is offered for a carsharing initiative for at least 10 participants.

The central government is interested in the environmental spin-off, as well as the reduction of mobility in general. For instance the Dutch ministry of Transport, Public Work and Water management supports the organisation for shared car use (Stichting voor Gedeeld Autogebruik) and contributes to promotion campaigns.

Definitions for shared use of cars:

- Autodate: Dutch word for different forms of carsharing.
- Carsharing: a group of people uses a pool of cars. This can be commercial (Greenwheels) as well as within a company (KLM's Wings and Wheels) as non-commercial within a group of friends or neighbours.
- Carpooling: people driving together in a car at the same time, the car is owned (or leased) by one person.
- Carrenting: hiring a car for a period of a day or more from a commercial organisation. Often these organisation offer subscription services as well as delivery at home (Call-a-car, or AutoDelen Amsterdam)
- Shared car use: the British word for carsharing.

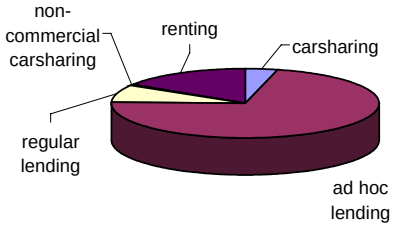
Functions of carsharing

The essential feature of carsharing is the fact that mobility instead of a car is offered. One uses a car when one needs one, without owning one. Also costs are in correspondence to the travelled distance (or time). In contrast to hiring, carsharing uses a pool of cars for a group of participants and the using time can be as low as one hour. The cars are equipped with electronic devices so the user can take the car from a parking, drive it, filling the petrol without the intervention of someone else. Once a month the user receives a bill in which all costs are included (petrol, time of use, insurance, contribution to raid service, etc). Carsharing suits people with a low mobility demand (about 10,000 km per year) and a low user's frequency (less than 3 times a week) (Stichting voor Gedeeld Autogebruik, 1997).

Since carsharing sells the *utilisation* of the product, it demands a new approach to product design. Carsharing provides part of the mobility of its participants: this is part-time use and part-time ownership. Since essentially *mobility* is offered, companies like Greenwheels co-operate with the Dutch railways.

In the traditional situation, either someone owns a car or uses the public transport system and uses a car occasionally. In the Netherlands, the following picture holds:

- about 6 million cars are privately owned,
- 800,000 cars are under a lease contract,
- many use a car on a temporary basis. This means lending from friends, family or neighbours (450,000 people per year), 50,000 lending on a regular basis (sometimes with paying), and more than 100,000 people per year hire a car for a period of a day or more,
- new car-sharing concepts (pooling a car within a private initiative and commercial carsharing) have approximately 25,000 participants.



Reference system

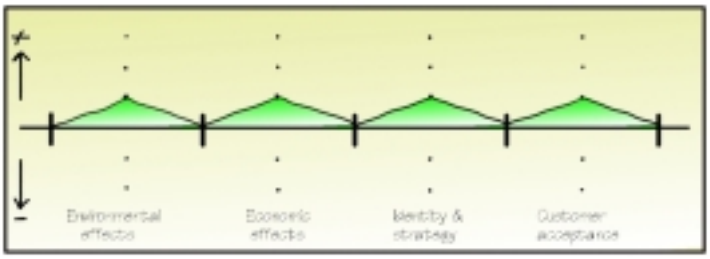
Changing (from own car or no car) towards carsharing has consequences for the number of cars needed to fulfil a certain need for mobility. It even turns out to cause a total change in mobility patterns.
The reference situation can be determined by looking at the mobility of participants before they were participants of commercial carsharing systems. In this case study, a person is considered who wants to choose between replacing his old car, buying his first car or becoming a participant of a carsharing system. Non-commercial activities are not considered.

The user or participant does not own a car himself, but becomes a participant of a fleet of cars. In the Greenwheels and other carsharing systems 1 car is used for about 15 participants.

Total mobility or car mileage of (potential) car sharing participants is difficult to define. Results of others are listed below:

- A Dutch evaluation program concluded that the average auto mobility of participants is 10,080 km, for those who had a car before (Meijkamp and Theunissen, 1997). This represents the average need of prior car mobility of a participant who chooses between buying a car or becoming a participant.
- Financial breakpoint between owning a car and a representative way of car-sharing (Greenwheels, or discount possibilities at regular car hiring companies) is between 10 and 15,000 km per year (Consumentengids, 1996). International surveys show cost-effectiveness at varying between 6830 km (Baum and Pesch in Muheim, 1996), 9000 km (AutoTeilet Genossenschaft Switserland), and 18193 km Peterson in (Muheim, 1996).
- CBS assesses the yearly average mobility per vehicle in the Netherlands. This is of course an averaged distance, which causes a few difficulties: participants of car-sharing systems are not average. The number of persons per vehicle is unknown. Meijkamp studied frequency of car use. This information was hard to translate into car mobility per year.
- It is assumed is that participants of a car sharing system drive 30% less compared to the reference situation. Meijkamp and Theunissen (1997) found 33%, while in a car sharing system in Berlin a 42.1% reduction was achieved). Since the average Dutch mobility by car is 16,560 kilometre per year (CBS, 1995), the mobility of car sharing participants should be 11,592 km per year.

Panel assessment



Environment

The researchers estimate that carsharing has a small positive effect on the environmental pressure caused by mobility: +1 on the axis:

- Dominant environmental load by using the car (environmental effects per km)
- Less mobility by cars , more public transport
- Less cars need to be produced, maintained, repaired and disposed
- Less parking space.

Economy

On company level, carsharing has a positive score (+1):

- Carsharing introduces a new service that is appreciated by a small but growing number of client (niche market).
- The new system adds economic value (high km/hour-price plus monthly subscription fee) that covers the costs of the system at growing number of subscribers
- Increase of employment due to service back-office.

From a macro perspective the picture is less positive (-1):

- Due to the reduced use of cars, economic activities like production, maintenance, repair and disassembling will come under pressure. Suppliers of

car parts will generate less turnover, etc. As a positive effect, more people will take lessons to get a drivers-licence.
- Car sales can be expected to go down on the longer term.

Strategy and identity
For the automobile sector, carsharing is a new player. Therefore new strategies and identities arise:
- As the traditional actors in the automotive industry (sales and hiring) showed much hesitation to embrace the carsharing concept, new organisations such as Greenwheels had a leading role. They are small and lack financial power.
- Initially there were aggressive responses of car hiring organisations. Today, the new actors meet growing competition from traditional player with similar market offers.
- Support of Dutch Railways.

Overall this gives a positive score (+1) on this axis.

Customer acceptance
For a specific group of clients, carsharing offers a new possibility for their need for mobility. This group however, is small compared to the total auto mobility in the Netherlands. For this reason the client acceptance is slightly positive (+1).
- A car is a status symbol (high emotional value) and many people want a car in front of their home (convenience).
- Small market, but annual market growth is high (30% additional subscriptions).
- Parking problems are solved, no need for individual parking permits (limited and expensive in the big cities).
- The client has a wide choice how to fill in his needs for mobility
- Today, carsharing subscribers are mainly critical highly educated people in big cities. They could have an emanation to a greater audience.
- Carsharing can be a good alternative for small villages were public transport is not available (any more).

Epilogue

Carsharing is a interesting and promising concept. The market for mobility is very large. Even a relative small market share could bring interesting business opportunities.
Transport is responsible for major expenditure in both the household and company budget. The environmental impact of transport is high. Carsharing is expected to provide more effective mobility solutions, mainly as result of the changing habit patterns of its participants.

Chapter 5 will describe this case into more detail, providing a better understanding of the economic and the environmental effects.

4.11. Timesharing of luxury yachts

Luxurious goods like yachts, large caravans and private aeroplanes are not particularly associated with good environmental practice. Often, responsible environmental care is synonymous with austerity. Especially design and architecture disciplines have expressed that for decades by a very strong modernism and supermodernism style. So a private (wooden) sailing boat in the eyes of the Dutch is definitely a sign of civilisation. Powered (polyester) yachts are quite the contrary.

Reality of today is that our harbours are filled with luxurious yachts, our campings with caravans, and private jets do exist even in Northwest Europe.
We see that a growing number of people participates in what we can qualify a luxurious way of recreation. They want to travel, rest, spend time with friends or want to meet new people (social aspects).

In this report we focus on collective ownership (time-sharing) of boats, whether powered or not.

The average use period of yachts is annually 30 to 35 days. That's not even 10% of the time. These 10% days apparently are so important to the owner that the 90% non-use is accepted. TMC is a consultancy specialised in adding financial, organisational and legal services to yacht-owners in such a way that collective ownership becomes a very serious option (Lohman, 1998). This makes boats a means of recreation for a larger population and a means of social club forming.

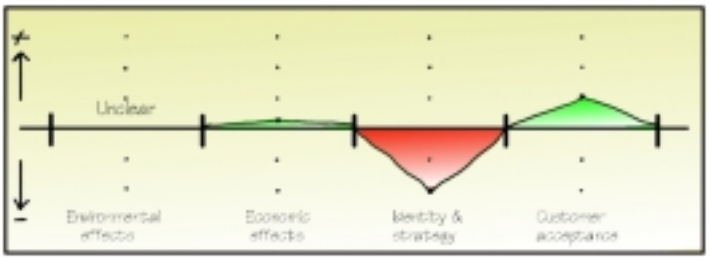
Function of timeshared boat ownership

In case of subscribing to a carsharing system, function fulfilment is offered. One buys the *use* of a car, not the *ownership*. The user group usually stays anonymous. There is no strong bond between product and payer. Therefore, it may not be the answer to your basic desire to possess a luxury good.
In case of *timeshared* ownership this differs. A distinct legal entity, an association, is founded in order to buy the durable. This enables to make legal arrangements for a wide variety of events. Co-owners (approximately 8 persons) buy shares and attached to these, the partial right to use the durable, for instance during 80 days. Co-owners are the association's officers.

The function of a timeshared owners*hip* (☺) is to own a product that serves you during holidays, to have the legal right to call it yours, to share experience with a selected group of co-owners and to reduce boat costs.

Traditionally one buys or rents a boat. Boats that are bought generally stay in the harbour for over 90% of their time, not being used. In case of renting, the average application rate is of course much higher.

Panel assessment



Environment
Defining the reference system is quite tricky. The simplest reference is a part of the co-owners buying a cheaper yacht on their own, and others hiring it every now and then. Every owner pays for stalling and maintenance services (e.g. anti-fouling) separately.
However this is likely an unrealistic reference. Since boats do not represent basic needs people probably switch very easily spending their savings on other products or services: a cruise, high-end travelling, or even buying an old-timer car. So perhaps the best would be to compare with the average environmental load that is caused by this consumer group during spending their leisure time. Here our defined *E2-vector* is useful.

Adding the legal service is supposed to be insignificant for the environmental.

Since this case represents a group of solutions, the panel has no opinion in general about the environmental burden of timeshared boats. It should be judged case by case.

Economics
For owning a ship of, say 12 meters, fixed costs are about € 14,000 per year (costs of buying, maintenance, dock dues, etc). Timesharing this ownership divides this amount by the number of co-owners. Each co-owner funds his or her buying share. As result of the legal construction, a co-owner is not liable for other's stupidities or accidents.
In the concept of TMC each co-owner buys "usetime tickets" and has the right to sell these to or trade them with his/her fellow owners. Prime time tickets are more expensive than others are.

At company level, the panel expects overall economic potential to be limited (0)[16]:
- On the one hand a timesharing system will compete against traditional hiring of a boat and selling a boat to a single customer. From both sites, the market is under heavy pressure.
- Overall, we expect that the commercial value of time-sharing will remain limited. However, a perfect network, communication and selling approach could prove that our score is to negative.

Identity and strategy
Strategy and Identity aspects are judged as *negative* (-2).

[16] From a macroscopic level, time-sharing will yield into reducing the total amount of added value as hiring and selling to single clients are expected to create more value. For regional economy, the economic value could be positive in case the co-owners would spend their holiday time here instead of in exotic countries.

- The yacht building industry is a traditional sector. Timesharing is a new 'service' concept. Specialised intermediates are needed to deliver the PS system to the market. Compared to the situation of a single buyer, it is a complicated way to sell a boat.
- Third parties like TMC consultants could catalyse the introduction of timesharing, but they will need strong partners to turn over the sector to incorporate this concept.

Consumer acceptance
TMC states that over 20% of the cases a Dutch private yacht is owned by more than one owner. TMC estimates the market for renting six times larger than buying. This should indicate a large market for timesharing.

Client acceptance is regarded as slightly positive (+1) by the panel.
- Most yachts are used only several weeks a year; the system offers almost full functional use of a luxurious yacht, sharing the costs with others.
- A yacht is a status symbol, with high emotional value. Timesharing people are considered to be smart entrepreneurs.

However there are serious drawbacks for market acceptation of the sharing option:
- Regularly hiring a boat is much easier and does not ask long-time commitments.
- Many discouraging examples of corrupted real estate agents in exotic countries have made consumers and NGOs very suspicious. Additionally private boats do not fit automatically in our cultural *communis opinio*.
- Finally, timesharing is still a white spot in the Dutch law.

Epilogue

Time-sharing offers functions that match the human desire to own luxurious goods and build up an emotional bond. Focussing on time-sharing of luxurious goods shows dilemmas of traditional environmental optimisation thinking. Our E2-vector concept (connecting environmental load with economic value) turns out to be useful rather than LCA alone, although the reference situation is quite hard to define.

4.12. The Chipper electronic purse of Postbank

In The Netherlands, Postbank has a share of 50% of all bank accounts. This means about 7 million clients. Electronic payment in shops has been organised quite differently from other countries. While in most countries credit card companies like Visa and MasterCard have taken over the electronic payment market, Dutch banks (Postbank included) have defended themselves effectively with a distinct card system, the so-called PIN-pas. A magnetic stripe on the card identifies the user. The shop-owner automatically contacts the bank to see whether the client's balance is favourable, and then instantly money is electronically transferred from the user's to the shop's account. It's a debit system rather than a credit system. The Dutch have adopted this system massively, since it's cheaper and faster.

In 1997 Postbank introduced the Chipper as a card for small amounts. The well-known PIN-pas had been enriched with a microchip and memory positions. This memory acts as an electronic purse. Other Dutch banks have since then introduced a similar card: Chipknip (Dutch for *Chip Purse*).

Function of the Chipper

The Chipper is a product. It's part of the PS system called giro account. For this case, we concentrate on private use having four functions. Firstly it acts as the familiar PIN-pas: a handy means of identification needed during real-time giro transactions in shops and pubs. This part of the system is used for payments between 35 and 500 guilders.

Secondly the Chipper acts as electronic purse for small change. The memory contains information representing ready money: bits and bytes in stead of coins and paper. The charging of the Chipper is done in public (adapted and everywhere available) and private telephones and special chargers for home-use. The Chipper's small payments are not made instantly, but transmitted batch-size. PIN-transactions are cheaper than credit card transactions. Chipper-transactions are faster and cheaper than PIN-transactions.
Postbank's aim is to introduce the Chipper in all places where electronic payment is possible: parking, vending machines, libraries, public transport, and so on.

Thirdly the Chipper is meant to be introduced as a safe and cheap means of distant identification (where signatures are now needed) and distant authorisation for distant payments. Useful for renewing your driving license, tele-ordering by telephone or Internet, etceteras. In case of moving, the user can change the address and town name data himself in the microprocessor (in the near future).

Fourthly the Chipper can contain data for third parties. The chip's memory positions can be rented out by Postbank, for instance for trading stamp book use or subscription details.

Reference situation

Just now the Chipper is slowly gaining market share. The charger infrastructure has been put up. As a reference we take the situation where the Chipper is massively used as a means of small change payment and identification (which might be the case over five years from now).

As a reference we chose:
1. Payment of 2000 amounts of € 16 (Dfl. 35) with an average of € 8 (Dfl. 17.50.)

2. Take out of € 16,000 by 200 portions of € 80 (Dfl. 175).
3. Identification in 100 various situations.
4. Keeping up of two trading stamps books during 2 years.

Alternative options

The end-user has options for all four functions.

Payments

The traditional purse delivers small change up to € 16 (Dfl. 35). This system includes: coins and notes, cash register, safe and sorting machines at the local bank, security vehicles, check and packing machines at the Dutch National Bank. The Dutch use the PIN-system occasionally for small amounts. Credit cards are hardly used for this.
Despite the rich possibilities, the Chipper lacks some functions as well. The substantial feeling of coins and notes (weight, symbols, and tradition) disappears. Tips reduce. Street musicians won't favour the system either.

Taking out cash

Taking out cash (typically € 80), with the Chipper is done in:
- public phone booths on the streets
- chargers developed by Postbank
- home used chargers (connected to PC with modem or telephone)

This will partly take over the cash points in the centres of town.

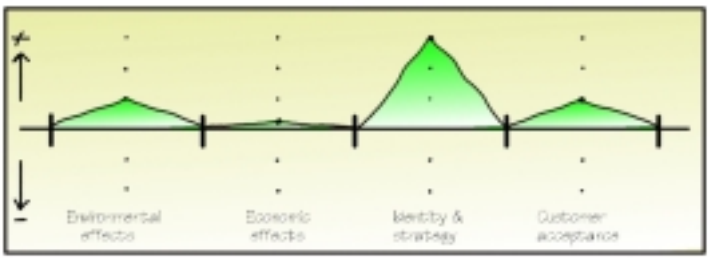
Identification

The identification now is done by means of:
- travelling by bike, car or public transport to town hall, post office, etc.
- credit card identification via Internet or telephone.

Trading stamp books

Trading stamp books are mostly designed as electronic card programs.

Qualitative assessment by the panel



Environment

The panel discussion has lead to an environmental score as slightly positive: +1.

The Chipper replaces any traditional identification papers like passports. It replaces notes and coins, and travelling by bike, car or public transport to townhall, postoffice, etceteras.

Postbank expects a decrease of ready money: less nickel, chrome, copper, paper, security transports, people driving their vans to empty vending machines. For help yourself sites like parking meters and vending machines Postbank foresees a market share of chipcard-payment of nearly 100% within 5 years. The change from guilder to Euro will contribute to that: the machines must be changed anyway. For public

transport Postbank foresees a dominant share as well. Shops will keep up four systems: cash, PIN, Chipper/Chipknip and, with a small share, credit card. In shops Chipper/Chipknip should be able to take 50% of payments under € 11,5 (Dfl. 25) within 10 years.

A new administrative organisation has been established for the Chipper. About 225 employees have tasks like: service the infrastructure and market the Chipper system abroad. Parts of the client service department (i.e. card supply) and the call centre are carried out by the back-office organisation of Postbank.

21,000 public phone booths do not need extra materials or energy use due to the Chipper extension. About 4.500 outdoor chargers from competitive banks have especially been installed for their competitive Chipknip infrastructure.

The home chargers have especially been designed. About 12,500 have been sold up to now. This charger has dimensions like a small telephone. This telephone should partly be accounted to the Chipper system, since it's a normal telephone as well, with storage of phone numbers and an answering machine. Dimensions and materials of this phone: about an average telephone. In 10 years about 2,5 million Chipper telephone-chargers will be needed.

An electronic reader (dimensions like a key ring), enables to read the user's balance. About 3 million readers will be supplied (for free) with an exchangeable battery.

A few million Chipper cards (PVC laminate) have been provided. It has been a complete update of all traditional PIN-cards. Each Chipper has been send together with paper memory help for five 4-digit identification codes.

Economics

The panel discussion has lead to an economic score of neutral (0).

As far as we know no ROI estimates have been done. Aim has been to reduce payment costs. Chipper/Chipknip can be regarded as medium-term investment by the banks.

Postbank hardly earns from the Chipper; cards are supplied for free and the price of the charger is sponsored. Chipper pays the installation costs at the retailer (average installation costs € 70). If 150,000 retail spots accept Chipper payment, Chipper expects 7 million Euros installation costs. Charging the card through telephones costs € 0.10 per minute. The seller can choose: either to pay 8% per transaction, or € 0.05.
Since transactions are transmitted batch-wise, very low amount telephone costs are accountable to each client's payment. Each retailer pays monthly € 7 (Dfl 15) for subscription. The end-user only pays as soon as he (she) buys the Chipper telephone or a dedicated charger. A charger costs him € 23 (Dfl 50). A Chipper telephone costs € 70. Supplying free balance readers costs Postbank about 1.1 million Euros.

Chipper telephones are sold via a distinct distribution channel (so-called Primafoon shops). Adapting public telephone booths did not lead to explicit costs.

General promotion costs about 5 million a year. Helpdesk costs are difficult to estimate since it has been integrated in the general helpdesk of Postbank.

Costs for collecting and recycling cards as well as recycling of electronic devices are unknown yet.

Identity and strategy
The panel discussion has lead to a strategy & identity score: highly positive (+3)

The Chipper organisation has been established 3 years ago, especially for the Chipper-system. For this, Postbank, KPN Telecom and ING-bank had formed a joint venture. Strategically spoken the aim has been to innovate in order to defend against new entrants in the market: other banks and creditcard companies. The Chipper is a strategic offence. Chipper has helped to strengthen the innovative image of Postbank.

Client acceptance
Panel discussion has lead to a client acceptance score of: slightly positive (+1)
Hardware enthusiasts amongst all target groups have adopted the system first. ("But they are only 100,000 amongst 6.5 million clients"). Massive client acceptance is not yet realised and is not expected at short term. Slowly payments are rising each month. The media still react very sceptical. Advantages over 'real money' are still small. Chipper still has quite some way to go towards general adoption. The panel believes that acceptance will rise (more or less by force) as soon as public transportation will be paid electronically by chipcard, as parking meters and vending machines.

4.13. Koppert: Biological Pest management

Biological pest management using natural enemies

Koppert, a family business established in 1967, is the international market leader in the field of biological crop protection and natural pollination. Large-scale production of natural enemies and pollinators takes place in modern production facilities. Systematic testing in Koppert's own laboratories ensures both quality and continuity. In the field of packaging, transport and storage-life, Koppert proves to be innovative and authoritative time and time again.
Customer satisfaction is essential for Koppert: growers must achieve results with biological control and natural pollination. Advice, guidance, provision of information, and training helps to achieve these goals.

Today, integrated pest management is used by approximately 90% of the Dutch growers. This is a good step toward growing fruit and vegetables with fewer pesticides. However, the use of chemicals is not abandoned.
"Bio-plus" of Koppert is state-of-the-art in biological control. It includes a "biological system" that describes how different natural enemies can best be introduced for different diseases or pests. Insecticides or acaricides are no longer needed, not even in the nursing of the plants.
It is the latest type of service currently tested and offers a complete biological pest management solution for greenhouses. It needs strict checks (so called “scouting”) on the condition of the plants, done by Koppert’s advisors or by the growers. The success is depending on many factors such as the climate in the greenhouse, sunshine, type of crops and the use of pesticides (also by neighbouring growers).
In the test phase farmers paid an fixed fee per hectare with no additional charges for the use of natural predators.

Functions of the PS system

Koppert identified several supplementary functions for their Bio-plus service:

Marketing
Complete biological pest control is attractive for supermarkets that wish to promote themselves as environmentally responsible. Growers who follow the Bio-plus programme hope to obtain market reference in a highly competitive market.

Educational
Regular courses are given to teach growers ho to recognise certain pests and how to control them with natural enemies. CROP-it software is developed to support this. Further posters and a website are developed as additional information sources.

KOPPERT
Biological Systems On-Line

Mentoring
A personal advisor/mentor visits and advises the grower on a regular basis.

Reference situation

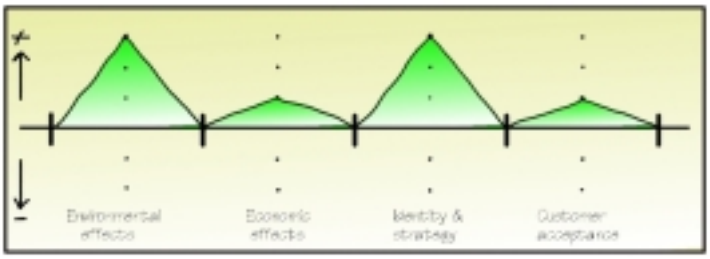
There are several methods to control diseases and pests. In decreasing order of application of chemicals, these are:

1. Supervised control: Chemical control when observations show that a disease or pest may cause economic damage.

2. Integrated control: Control of diseases and pests at acceptable levels, using a number of techniques (including biological control). The techniques used are chosen from an economic point of view, but are nevertheless environmentally sound. The use of chemicals is minimised.

Other ways the PS system can be described are simply not spraying, giving huge product losses. It is also possible to buy loose "natural enemies", but this doesn't give the support Koppert gives and involves a great risk as generally a farmer does not have sufficient expertise.

Assessment by the panel



Environmental analysis

Koppert identifies as most important environmental aspects of the Bio-plus system:

1. -no pesticide use
   -no residues left on the produce
   -no sprays to the environment
2. better occupational health

As greenhouses have a high consumption of pesticides the environmental gain can be high (highest panel score: +3).

Pesticide use in the Netherlands	
Farm type	**Active substance (kg/ha)**
Open air vegetables	16.3
Greenhouses	77.7
Mushrooms	106.9

Economic analysis

Currently the Bio-plus option is € 0.7 per square meter (Dfl.1.50). This is € 0.1 more expensive than normal integrated pest management. For first experiments subsidies were given and Koppert agreed to cover all costs above € 0.7. However the difference is too much for commercial success without any subsidies or regulatory measures. For this reason Koppert had the Bio-plus nominated as a environmental reference project[17] (Senter, 1998).

Currently a certification scheme and label is set up to enhance the visibility and marketability of biologically protected produce, so that higher prices might be paid to cover for the higher costs (Slightly positive score by the panel: +1).

Strategy and identity

The PS system is mainly strategically driven (highest panel score +3).
Koppert's change to a more market and service oriented company was started by a change in management. Development of new products is now related to market demand. In the past it used to be research driven. The change involved additional training for personnel and investments in classrooms and supporting tools like

[17] This Subsidy program is for market introduction of environmental technology from SME's and financed by the Ministry of Economic Affairs.

software, a website and Intranet facilities for customers. Responsibilities have been delegated from management levels to lower levels.

Consumer acceptance
Most clients of Koppert do accept the approach, but price differences may still be too high in some situations. This yields a slightly positive score (+1)

Epilogue

Koppert has incorporated a very innovative strategy that has positive contribution to the environment. Customer acceptance turns out to be the critical factor, partly as result of higher prices, partly as result of the new concept. Growing interest of consumer for eco-food and quality food may be expected to stimulate the acceptance of this new PS system.

4.14. Conclusions on ten examples

The ten cases in this chapter illustrate the potential of PS systems for a more sustainable economic growth in the future. In six of the analysed cases, the panel assessment shows positive scores on both the environmental and economic axis. These are printed bold in the table below that summarises all panel scores. Again we emphasise that the panel discussion always yield subjective results.

In the next chapter, three of the cases with both positive ecological and economic scores are analysed quantitatively by the E2-vector concept. These are: Odin's organic food subscription, Greenwheels' carsharing and Electrolux' Wascator.

	Environmental effects	Economic effects	Identity and strategy	Customer acceptance
Odin Holland B.V ***Organic food by subscription***	+3	**+1**	**+2**	**+3**
Gispen and Rgd ***Hotel Office***	+1	**+1**	**+2**	**+2**
Stybenex *EPS lay-out plan and take back service*	+1	0	+1	+1
Libertel *Free mobile phone set*	-1?	+3	+3	+3
Douwe Egberts Coffee System ***Coffee systems***	+1	**+3**	**+2**	**+2**
Electrolux Wascator	+2	**+3**	**+2**	**+1**
Greenwheels ***Carsharing***	+1	**+1**	**+1**	**+1**
TMC *Timesharing luxurious yachts*	?	0	-2	+1
Postbank *Chipper electronic purse*	+2	0	+3	+1
Koppert ***Bio-plus, biological pest management***	+3	**+1**	**+3**	**+1**

5. Quantitative analysis of PS system examples

Our project started with the idea that a shift to Product Service systems is a good way to lower environmental load per unit of value. We have taken three examples to study the value of this premise. These examples were also described in the previous chapter.

- Carsharing
- Laundrette-service
- Vegetables by subscription

The environmental load is expressed as milli-Eco-indicator points (Goedkoop, 1995), abbreviated as mPt.

5.1. Carsharing

On page 74 a description and assessment of carsharing was given. As we already noticed the functional unit in a carsharing system is a complex one.

If we want to compare the competitiveness of the carsharing system in combination to the environmental impacts, it is best to select a representative group that decides to join the system. This can be done both byselecting people who did and who did nothave a car of their own before joining. For the first group the mileage will decrease, for the second group the mileage will increase (Meijkamp, 1997). If we want to analyse the full effect of the introduction of this PS system, we will have to take both groups into account. For both groups it seems valid to assume that their appreciation of the carsharing system is high as they made the transfer to the new system by free choice.

In this case we are fortunate to have a very elaborate and detailed study at our disposal: (Meijkamp, 1997) compared the behaviour of people who joined a carsharing system with the behaviour they had before. For people that joined the system Meijkamp observed the following average effects:

- A decrease in the average transport distance by car: from 708 to 475 km that is 33%.
- A very modest increase of the use of public transport, from 660 to 730 km per month, or an increase of 11%. This low increase can probably be explained by the fact public transport is mostly used for commuting. The data only specifies the frequency of use, so the distances can only be estimated, when we assume a train ride is 42 km, a regional bus ride is 10 km and a city-bus ride is 3 km.
- A decrease of the number of cars. Before the system was introduced the number of cars in the group was 1296, after introduction of the system the number was 380. This means a reduction of 75%. Although this figure tells us how many cars are used at the same time, the total consumption of new cars is not determined by this figure, as these shared cars are used more intensively. Thus, they can be expected to be replaced faster. In first estimate, the replacement rate can be based on the mileage of the car only. As we have observed that the total distance travelled by car is decreased by 33%, the total consumption of new cars by the introduction of the carsharing system is (only) reduced by 33% compared to the reference situation.

We have chosen to take the following functional unit:
the actual transport behaviour of a person before and after joining the carsharing system, during a month. With this very wide definition we take into account the distances driven by car and public transport before and after the system is introduced, for the average user.

Thus, our analysis is not comparing the system on the basis of a fixed driving distance. It is not comparing the difference between the average owner of a private car and the user of a shared car, nor is it comparing the difference between having a car and carsharing. Instead this functional unit means we analyse the actual societal changes that occurred due to the introduction of the system.
To calculate the environmental load for the public transport, we use the following simplified approach. According to Meijkamp train covers 80% of the public transport distance. For trains it is relatively easy to calculate the electricity use, using CBS data. It shows that the electricity use is about 0,12 kWh per passenger km. We have little information of the environmental load of bus transport. As their share in the transport distance is relatively small we assume they have the same environmental effects as trains per km. The costs are based on a return ticket for a distance of 46 km (the average).

In the table below we have gathered the environmental data and the value creation data for a normal car owner, who drives 708 km per month in a small car (Peugeot 106) (Consumentengids, 1998). This type is often in use in carsharing systems like Greenwheels. We assume the car is used 5 years before it is sold as second-hand car. Then, the total driving distance is 42480 km. The environmental data is expressed as Eco-indicator points. We used several data sources for these calculations.

> Services included in car use
> In order to estimate the environmental load of the services we use (Vringer, 1997), who calculated the energy use per unit of value creation for professional services. This figure is 2.2 to 2.6 MJ per Euro.
> For car repair he estimates 3.3 to 5.5 MJ per Euro. (this figure excludes spare parts).
> The Eco-indicator value for average energy is about 0.1 mPt per MJ.

Car owning per month	Value creation (in € = 2,2 Dfl)	Env. Load (in mPt)	Comment
Production (depreciation)	110	120	
Interest	32	7	
Insurance	47	10	
Tax	17	4	
Gasoline use	71	250	
Maintenance	18	12	Env. Ef. of tire and oil change, plus service
Disposal	2	-48	Negative environmental load due to recycling
Public transport	80	45	
	377	400	

For the carsharing system we can produce a similar table. We will use additional data, based on the average use habits and the description of the procedures in the Greenwheels organisation.

Financial data used and the choices of allocation in our carsharing model

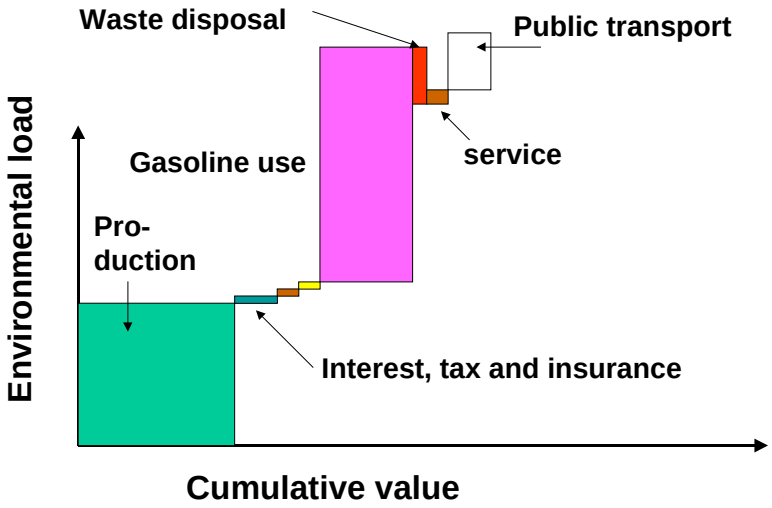
A difficulty in modelling a sharing system is the completely new price structure.
In modelling of the carsharing system we have decided to build the chain from different elementary blocks than the previous chain analysis. This is done for practical reasons. These blocks show a good match with the price and cost calculation system of Greenwheels. Thus, the activities 'driving' and 'using' combine the 'primitive' activities of the car-owning example (e.g. production, interest, gasoline etc.).

In addition, the allocation of the environmental load to economic activities is a difficulty. We have solved this as follows:
We assume the subscription costs are used to cover the carsharing organisation, the insurance, taxes and interest. By doing this we can assume the environmental load is 0.1 mPt per Dfl.
We assume the hourly rate is used for depreciation, disposal and the maintenance of the car. On average, the shared car drives 10.13 km/hr, this means it is used for 48 hours per month (at Dfl. 250)
The costs for driving the car are 0.15 cent per km, plus the gasoline use. We allocate all environmental effects from driving to this part.

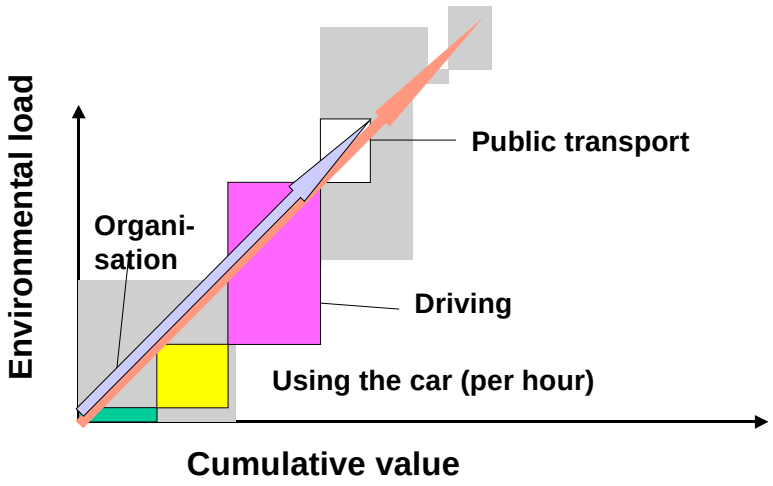
It is clear that we could also have taken a different elementary blocks and allocation rules. This would lead to a different LCA Eco-pool picture, but not to a different overall E2 vector as this represents the accumulated effects.

	Value creation (in € = 2.2 Dfl)	Environment. load (in mPt)	Comment
Subscription	40	9	Env. Load determined by carsharing organisation, insurance and taxes
Using the car (per hour)	43	88	Depreciation, based on 48 hrs per month
Driving	48	166	Including 0,15 per km additional costs
Public transport	90	50	
Total	265	281	

Before car-sharing introduction



Car sharing



In above figures we have plotted the E2 vectors for the situation before and after the introduction of a carsharing system. The Eco-indicator is used for the vertical axis.

It turns out that the angle of the vector is almost identical for both systems. However, the vector for the carsharing system is 30% shorter. In other words, the gain in efficiency of the new system has a considerable and combined effect on the value creation in the chain and on the environmental load. This means that the introduction of the carsharing system implies a transfer to a more cost effective and environmentally friendly way of transportation.

As explained in chapter 3, in this situation, it is still hard to predict the influence of the introduction of the system on the overall potential for unlinking environmental pressure from economic growth. Intuitively, driving a car is expected to have a steeper E2-vector than the average alternative consumption that is made possible by the saving of money. If this proves to be the case, carsharing will contribute to unlinking environmental pressure from economic growth. This assumption, of cause, still needs to be closely checked.

The overall conclusion that the E2 vector does not change fundamentally by the introduction of carsharing is relatively easy to explain: the service component by the carsharing organisation in the value creation is relatively small. The user's habits are different, but major elements in the chain are (almost) identical.

Closer analysis of the E2-vector pictures will learn strategies to improve the 'unlinking potential' of carsharing:

- If carsharing systems could use specially designed cars, for instance hybrid cars or cars with increased mileage. By this the unlinking potential could improve.
- The perceived value of car sharing could be improved, by additional services or by convincing the customer towards ECO-surplus payment. Governmental bodies can indirectly influence perceived value by policy, e.g. information and tax instruments.

A major environmental benefit of carsharing could not be included here: there is a considerable (75%) decrease of the use of parking space. This benefit could not be

included, as the Eco-indicator 95 method does not weight land use. If it could, we would probably see a positive unlinking effect.
In specific urban situations, (e.g. the city of Amsterdam) the cost of parking can be very high and should also be taken into consideration, underlining the fact that our pictures describe average situations and should not be used for individual decisions without thought.

5.2. Laundry-services

Electrolux is stimulating the development of local laundry services. As a rule a laundry service can operate in an area with about 15,000 inhabitants. The reference situation of the laundry system is the privately owned washing machine and in many cases a tumble drier (see also page 71).

A brief look at consumer behaviour

An important aspect is the consumer behaviour, when analysing privately owned washing machines. This information is difficult to get and has to be partly based on assumptions.

- In the first place it is logical to assume, that the private owner of a washing machine washes clothes more frequently, as the machine is always readily available.
- Secondly, while it is logical to assume that in a laundrette the machines are loaded to full capacity, privately owned washing machines are probably loaded much less efficiently.
- An important factor is the tumble drier. In 53% of the homes a drier is available (EnergieNed, 1998). It is unknown to what extend the users of a laundrette would use a drier if they decided to purchase their own equipment. Dryers are mostly used in larger families with children.
- Smaller families or singles are more likely to be the typically users of laundrettes.

In a laundrette drying is always and ironing is generally included. It is difficult to separate the energy use for drying and washing as these machines are linked, they use the same heat source and surplus energy produced in one system is fed into another.

As we do not have much data on these aspects, we calculate two reference scenarios by making following choices for the functional unit:

1. *Basic home-washing scenario*: The amount of laundry is equal for the reference system and the laundry service, the privately owned machine is used to maximum capacity, and we assume that the typical user of a laundrette would normally not use a tumble drier at home.
2. *Convenience home-washing scenario*: The amount of laundry in the reference system is 1.5 that of the laundry service, The privately owned machine has an average load of 3 instead of 4.5 kg and we assume that the 50% of would use a drier at home.

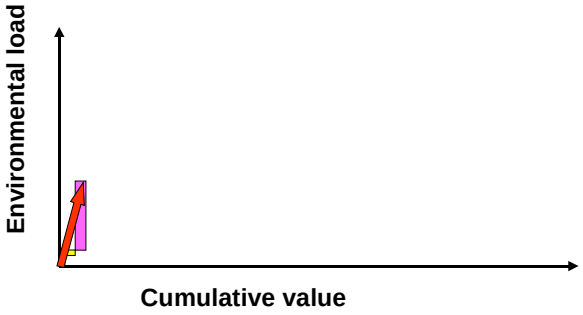
An important factor is the use of detergent. For reasons of simplicity, we assume that the total amount of detergent in the laundrette is equal to the total amount of in the privately owned machines.

In the table below the results are summarised. All data are presented as a percentage of the laundry system.

	Private machine				Laundrette	
	Assumption 1		Assumption 2			
	Value	Env. Load	Value	Env. Load	value	Env. Load
Production	1%	2%	3%	5%	9%	2%
Retail	2%	1%	6%	2%	0%	0%
Tax	0%	0%	1%	0%	0%	0%
Energy	2%	26%	13%	136%	78%	93%
Disposal	0%	-1%	0%	-3%	0%	1%
Total	5%	28%	23%	140%	87%	96%

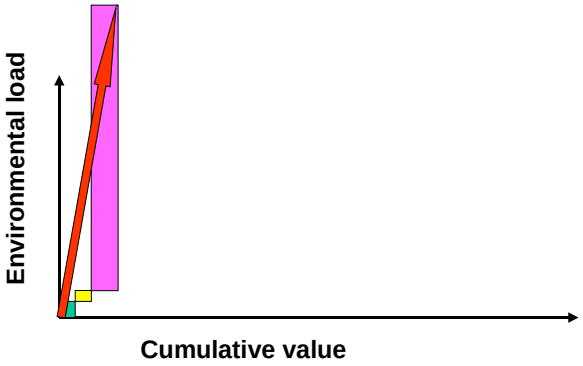
Private washing,

4,5kg/charge, no drier, equal amounts

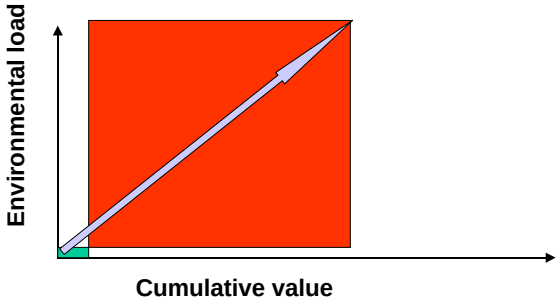


Private washing,

3kg/charge, 50% drier, 1,5 times more



Laundry service



The results of the analysis are plotted in above figures. The Eco-indicator is used for the vertical axis. The conclusion is that the outcome is very much determined by the assumptions on consumer behaviour:

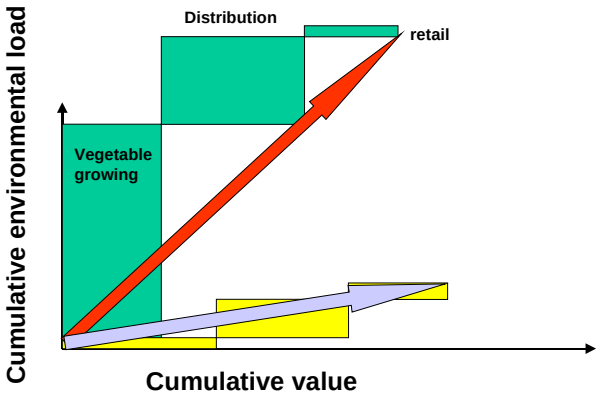
- In the Basic home-washing scenario, the environmental load of the PS system is much higher than the reference. Compared to the Convenience home-washing scenario, the PS system has a much lower load.
- In both scenario's, the value creation in the PS system is considerably higher. As result, the PS system has a large 'unlinking potential'. The system converts typical 'unpaid' household tasks into services with a significant perceived value.

5.3. Vegetables by subscription

Purchases of vegetables by 10,000 subscribers of the subscription system are chosen as the functional unit for this third case study. It is unknown (and virtually impossible to determine) what people purchase in addition to the subscription. Thus, we restrict the analysis to those vegetables bought by subscription.

Most of the environmental data for this study are taken from (Spriensma). These data are the result of elaborate study. The economic data are briefly described in the case description of the previous chapter (page 54).

	Subscription		Shop	
	Value	Env. Load	Value	Env. Load
Farmer	45%	2%	20%	643%
Distribution	30%	98%	36%	245%
Shop	25%	0%	24%	0%
Total	100%	100%	80%	887%



The results of the analysis are plotted in above figure. The Eco-indicator is used for the vertical axis.
The angles of the E2 vectors of PS system and reference are very different. A more or less equal cumulative value is created by the vegetable subscription system, against much lower cumulative environmental load.

The differences are caused by two major factors:
- The PS system is based on pesticides free production. Pesticides have a high weighting factor in the Eco-indicator 95.
- The distribution channel for the PS system is more efficient, in terms of transport and the amount of packaging material.

It should be noted that the effects of land-use are not included in the analysis. Ecologically grown vegetables need about 30% more space.

These results suggest that this PS system can significantly contribute to unlinking environmental pressure from economic growth.

5.4. Conclusions regarding three cases

E2-vector concept

The three case studies show the usefulness of the E2 vector. The E2-vector provides a new and valuable view to address the ecological and economic effects of system innovations by a method with great communicational power.

The case analyses could be made on basis of the available ecological and economic data and making use of Eco-Indicator 95 and LCA software. The availability of good data is crucial for the E2-vector assessment and should be checked carefully. In the three cases we were lucky that good quality data were at hand.

We feel confident that the results presented in this chapter are both useful and valid, making following restrictions:

- It should be recognised that the choice of the reference system, the functional unit and assumptions in the allocation of economic and ecological effects can have important effects. Thus, citation of the results as presented here should always refer to the choices made.
- The analysis is a 'snap-shot' in time. When important changes occur (such as changing market situations or tax systems), new assessments are required.
- Most fundamental problems include the analysis and modelling of the effects of the introduction of a PS system on the actual changes of consumer behaviour.

In future studies, it is recommended to include a more elaborate sensitivity analysis on these points.

Based on these results, the application of E2-vector analysis is recommended as a tool in future studies and business decisions. Researchers expect that the E2-vector concept could contribute in strengthening the new thinking initialised by the Dutch Policy Document on Environment and Economy.

Results

The E2-vector analysis of the three PS systems presented in this chapter shows a (major) potential of these systems to make our future more sustainable, as summarised below:

Environmental impact per unit function fulfilment (vertical axis):

++ For the system changes towards carsharing and vegetables-by-subscription, the environmental load per unit of function is reduced significantly.
+/- For a Laundrette, this is not clear, as much depends on the assumptions of consumer behaviour.

Economic impact per unit function fulfilment (horizontal axis):

++ Transfer to Laundrette services will increase market size.
0 Vegetables-by-subscription will leave the market size more or less unchanged
- Introduction of carsharing systems will decrease the size of the market for personal transportation (lower average distance travelled by car, lower number of cars on the road, improved economic efficiency of transportation).

Unlinking environmental pressure from economic growth (vector analysis):

++ The Laundrette and the vegetables on subscription clearly contribute to unlinking, as the tip of the E2-vector is redirected towards more favourable sectors in the E2- diagram.

+? Carsharing can be expected to have unlinking potential as well, under condition that the average alternative consumption (made possible by the saving of money) is more sustainable than driving a car.

6. Conclusions and recommendations

6.1. Conclusions

General conclusions

In this project we have explored the world of the Product Service systems. We have introduced concepts and tools to better describe, understand and assess these systems.
We consider PS systems to be of interest for business society, policy makers as well as Non-Governmental Organisations (NGOs).

1. PS systems are a known phenomenon. A vast variety of PS systems can be found in practice. Their number is growing. In this project we analysed ten existing PS systems. By this analysis we learned that the PS systems concept offers high potential for sustainable growth. Of course we realise that the understanding of individual cases can only be a first step towards a more general appraisal of the PS systems concept. Still, the lessons learned and the new tools made available might be helpful to assist the development or redesign of product systems or Product Service systems in such a way that the changed PS-mix reduces environmental load while business value increases.

2. The viability of any PS system depends at least on three criteria:
   a) Business economic prospects,
   b) Company's identity and strategy,
   c) Client acceptance.
   In this study, focus was on the relation of environmental aspects with these criteria. To properly address the environmental effects, two more criteria for analysis are needed:
   d) Ecological impact of the Product Service system,
   e) Relation between commercial value and ecological impact.

   When analysing the sustainable potential of a business case, all these aspects are important. We have developed a general 4-axes model for PS system assessment on above criteria (a to d).
   - The instrument of Expert Panel has been tested in combination to the 4-axis model. We feel confident that the 4-axes panel method is helpful focussing on key issues and sharing knowledge, strategies and market impressions.
   - To further improve the quality of the environmental and economic analysis simple quantitative procedures have been proposed, e.g. by making an LCA-based profit pool and an Eco-pool analysis of the PS system. These pool concept prove to be powerful both as tools for analyse and communication.
   - Company's identity and client acceptance are additionally important for a company during the decision making process whether to set up a PS system or not.

   To model the relation between value creation and ecological impact (e), the E2-vector has been proposed. For three cases the E2-vector was calculated.

3. Both the qualitative 4-axes expert panel results and the quantitative E2-vector results show that individual PS systems can prove beneficial to the environment in combination to creating (new) business. Moreover, the E2-vector studies

show a potential to unlink environmental pressure from economic growth. Key-factors of success are similar in many cases, e.g.:
   - Creating value for clients, by adding quality and comfort
   - Customising offers or the delivery of the offer to clients
   - Creating new functions (new functionality can create new market demand and new types of need fulfilment)
   - Making smart or unique combinations of different functions
   - Decreasing the threshold of a large initial or total investment sum by sharing, leasing, hiring.
   - Decreasing environmental load. Often this will bring additional and perceived Eco-benefits.
   - Increase the quality (e.g. earlier in process, more personal or higher frequency) of the contacts with clients.

4. These case results and the lessons we learned about key factors of success (and failure) have given us the impression that the positive conclusions could be valid for a wider class of PS systems then we could include in our work. This should be checked in the future.

5. At the start of the project, we experienced that the concept of PS Systems was not always easy to communicate. Therefore, appealing PS system cases were selected and described. Models and tools have been made available that might prove to be of value in future communication. We hope that our report will be a great help to other people that wish to explain the Product Service system thinking and its potential for sustainable development. A second source of confusion was the diffuse terminology to describe this field. Therefore, we have developed a clear set of definitions for key words like product system, dematerialization, socio-technical systems, product and service, and the ongoing changes in production patterns.

6. The PS systems can be categorised by the process of their creation (Ps, Sp, PS, STCH). Furthermore, cases show that services can be added during all life-cycle stages of the product (from pre-design to retribution).

Relation with macro-economic trends

PS concepts often are a company's solution to world-wide consumer and business trends like mass individualisation, E-commerce and other IT developments, strategic product development, flexible working, the 24 hour economy, superior value offering, one-to-one relation marketing and environmental consciousness. The PS concept matches the national economic trend of an increasing GNP (gross national product) due to an increasing services share.

Business opportunities and drivers

During this project we have identified drivers and key business criteria that have led the development of successful PS systems. These are described in this report and will be helpful to other businesses in their strategic decision making.

1. Compared to Ecodesign cases, the transition towards PS systems will often imply an important process of change for the company towards new thinking on how the company should create value, produce, distribute and approach her clients.

2. Motives to add services to products vary widely (from client's problem solving via superior value delivery to reducing costs and following ideological principles). In turn, products are added to services in order to increase commercial value, to lower the entrance threshold for new clients and to reduce (infrastructure) cost.

3. In many cases, the introduction of PS systems is mainly 'strategy driven'. Not short-term financial benefits are leading, but the long-term vision on development of company's core-competence and customer relationships. Integration of adjacent business and enduring improvement of client contact can be examples of strategic drivers. Many of the cases in this project illustrate that the new package of PS activities can opens the way the towards a higher quality level.

4. The economic analysis of PS can be difficult, for example by:
   - The fact that the real value of the quality improvement is not always fully explored by the producer in direct financial terms. It is often used as long-term investment to improve loyalty of customers.
   - The fact that PS system can be beneficial over existing offers in the marketplace by combined offers (multi-functional offers) or offers with an increased quality level.

5. Two levels of economic analysis are important for a company that is planning to introduce a PS system.
   - Before introducing a new PS system, the economic consequences of the planned activities need to be analysed in depth at company level (micro-level).
   - Additional economic analysis at the level of the full value adding pool is important to find out the overall economic viability of the PS system and to determine most profitable activities in the pool (meso-level).

Ecological impact of PS systems

The analyses in this project show a positive perspective of PS systems for unlinking environmental pressure from economic growth. This might stimulate companies and policymakers to increase their efforts in the development of new PS systems.

1. Although many exceptions can be traced, service industries generally score better on the ecology/economy rate than product industries (see Annex).

2. Adding services in any of the product life phases can be environmentally advantageous (see results of Chapter 4).

3. The results of the case studies (in Chapter 4 and 5) illustrate the potential of PS systems towards a more ecologically sound society. However, they also show that not all PS systems will be ecologically equally interesting. In most cases, the environmental scores of the panel are positive. Only one of the PS systems that were analysed was suspected of a negative overall environmental effect. However, careful future analysis by the E2-vector method could provide a more complete overview, and include rebound-effects.

4. Ecological potential of PS systems should be judged case by case.

(Ecological) methodologies

4 axes model

The developed 4-axes model can act as a guide for assessing existing and potential PS systems. The first axis covers the (relative) environmental effects of the value creating PS system. The environmental analysis should enclose the complete picture of the PS system, in comparison to an existing offer with similar functionality to the customer. An analysis restricted to the company's activities could lead to sub-optimal solutions.

As consequence of the goal of the study, the second axis can be chosen to cover either the (relative) economic effects for the single company or the economic effects of all value-adding actors.

The third axis covers the company's identity and strategy. The last one covers the consumer's acceptance.

1. Case research followed by panel assessment can be used to get a first indication of the environmental score of the PS system, its economic score, the identity issues and the customer acceptance. Our experiences with 4-axes panel discussions in the case studies were valuable. As the results represent a collective impression of the panel members, these results can be regarded as supplementary information in the management decision making process. However they should be handled with care. Today, broad experience with PS systems is still lacking to trust on panel assessment only.

2. The general profit pool concept as marketing tool described in literature can be transformed into the Eco-pool concept. The profit pool concept can be extended into a more elaborated LCA-based system profit pool, including full life cycles of products and services and based on the functional unit of the system. Similarly the LCA-based Eco-pool can be defined.

3. Companies can use these two pools for analysing which business activities offer highest profit margins and lowest environmental load against cumulative value. Such insight is important for those who aim to develop sustainable business concepts.

4. 'Eco-pool' and 'profit-pool' are concepts that can be easily communicated.

5. Including services in ecological studies generally results in higher complexity than traditional product oriented studies. Taking services into account in environmental studies can be done but requires extra care (see Chapter 3).[18]

E2 vector

A second instrument has been developed so that the value of intangible services and the rebound-effect can be tackled. Plotting the cumulative environmental load against the cumulative financial value of all activities in a PS system results in a new tool: the E2-vector. This vector plots the ratio between the value creation and the environmental load of a total value creating pool.

1. Essential for the analysis of PS systems by the E2-vector is the choice of a wide definition of the functional unit, often to including the behavioural change of

[18] In some cases, the sufficiency of existing environmental accounting methods may be questioned (see Ch. 3).

customers. In most LCA's the functional unit (and thus the scope of the whole study) is a single product. In PS system analysis however, the functional unit includes a complete system. Still, the LCA methodology proves fully useful, although choices should be made with care (to guarantee that the reliability of the outcome will not decrease) (see chapter 3 and 5).

2. The E2-vector is an effective instrument to study economic and environmental performance and to demonstrate effects of uncoupling environmental load from economic activities. The E2-vector opens the opportunity to analyse the changes of the absolute environmental load in relation to the value creation of a business network (see Chapter 5).

3. Broadening the scope, results of E2-vectors opens the way for discussing and analysing rebound effects in society as result of system changes (see Chapter 3).

4. Many PS systems innovations include change of infrastructure. Quite the contrary to usual Ecodesign and other LCA based projects, this means that *infrastructure* should often be taken into account. This in accordance with current trends in LCA methodology developments. In many PS systems *human labour* is essential. Quite the contrary to usual LCA practices, this means that labour-related environmental effects should be taken into account as well. LCA methodology allows this (see Chapter 3).

5. The E2-vector definitely has proved to be a powerful communication tool.

6.2. Recommendations

In order to further explore the opportunities of PS systems several recommendations will be given below. Based on the results of our project, we expect PS systems to offer new environmental thinking in combination with new business opportunities.

Communication

One follow-up of this project should be a communication on this subject to a wide audience. The first steps were already taken within this project, but further exposure and discussion is necessarily. This communication should be initiated from as well governmental organisations, intermediate business organisations, NGO's and the researchers themselves.

1. The outcome of this project should be deepened and hardened during cross-disciplinary discussion sessions with specialists on product marketing, service marketing, new business development, environmental design, business economics and policy making. Workshops and articles might be adequate means for this.

2. Idea exchange should be facilitated (e.g. by the Ministries) with representatives of currently run research projects. The results of this project may help the other researchers, and the ideas will be checked, improved and validated.
   - For example: the Sushouse project (The Netherlands/TUD, Hungary, UK), Eco-services for Industry (The Netherlands/IVAM, Germany, Italy, UK), Recycling services (Germany/IZT), Servus Programme (Sweden).
   - Additional international exchange should be facilitated with the Strategic Design Group of the Politecnico Milano in Italy, the Wuppertal Institute and IÖW in Germany, and the Manchester University in the UK and noticeable knowledge partners like UNEP (department Sustainable Production and Consumption).

3. We advice the PS systems concept not to be positioned as totally new and isolated. Evolution rather than revolution. The concept could therefore be positioned as a next innovation step in relation to Ecodesign or in relation to trends in the service industry.

4. The industrial interest for sustainable business is growing. Strategic communication on the E2-vector concepts could be started with industry. However it is advised to first check the industrial support for the E2-concept in the above-mentioned workshops.

Pilots

In order to explore the concept of PS systems in more detail it is advised that pilot projects should be carried out. The pilots should focus on two goals:

- to verify the developed concepts and tools,
- to show business society the possibilities of PS systems.

These pilots can be initiated from governmental organisations in co-operation with companies and industrial associations. This could provide a proper match with activities in ICT (or service sector) policies or provide follow-up of the Ecodesign programme as was run by the 'Innovation Centres', as thinking in 'system concepts' can be regarded as a logical next step in the development of strategic eco-management (e.g. ISO 14001).

1. PS systems open up new business opportunities. As documented in literature (Gadiesh, 1998), the profit pool can be a powerful search tool to explore these. Application as search tool could open the eyes of product oriented entrepreneurs for new business development and network innovations (see Chapter 3). Experiments with network innovation search will show the real value of this claim.

2. Once a profit pool has been drawn up, it is relatively easy to develop the Eco-pool from it and to determine opportunities to lower the environmental load of the business. Of course, it should be realised that the quality of the Eco-pool depends on the availability and quality of the environmental data.

3. Pilots must show the full potential of the E2-vector as business decision-making tools. In our project, we have shown that the E2- vector is an interesting tool to analyse the effects of the introduction of new business concepts. The instrument can be used in communication with governments and perhaps the general public (e.g. in public debates on sustainability, factor 4 and perhaps the goals set by the world council for sustainable business development).

Policy making

The concept and tools developed in this project are useful to policy making in general as well.

1. The E2-vector concept should be evaluated into more depth to be generally used in policy discussion on unlinking environmental load from ecological growth.

2. Business activities that have a lower environmental load per unit of value should be stimulated. The E2-vector should be tried as a tool for benchmarking several industrial sectors. A small database of profit- and Eco-pool and E2 vectors for key economic activities (such as different transport modes, several consumer product solutions, etc.) could be a very useful result for decision-makers. In the future, government could set up a stimulating program for ‘high E2-score’ PS systems.

3. The Dutch government, being one of the largest market parties in The Netherlands, could experiment with incorporating the E2-vector in their program Sustainable Purchasing.

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Definitions and abbreviations

Added value: the amount of money a company receives in selling a product or service subtracting costs of material input.

Dematerialization: changing a user's need fulfilment in such a way that either the overall material flows or energy flow of that need fulfilment decreases significantly.

Eco-design: design practice in which environmental issues are a key decision factor in the design process.

Eco-pool: graphical representation of environmental pressure in an interconnected group of activities together fulfilling a need.

Eco-wave: plot of the environmental load versus the profit made.

Functional unit, or unit function fulfilment: a standardised quantity of measurable function fulfilled by both PS system and reference system. A proper choice of the functional unit enables fair comparison between different design solutions. Functional unit will be a key word during the environmental and economic analyses of PS systems. In case of PS systems it may not always be possible to find a reference system with the exact similar functional unit. If we are to compare two products, we must be sure that the products are really comparable and have a comparable performance.

GSM: Global System for Mobile Communication

Ingredients: products delivered separate from a product or service, but can be essential for the fulfilment of the need of the consumer. Ingredient can be supplied by the producer of the service, producer of a product, by an associated partner, or an independent supplier (mainly electricity, water, chemicals etc)

Mass-customisation: production of mass goods, on consumer's wishes

PJ: Peta Joule

P/S-ratio: the ratio between the amount of product and service, either in terms of function fulfilment or economic value

Product service system: a marketable set of products and services capable of jointly fulfilling a user's needs, provided by either a single company or a strategic alliance of companies.

Product substituting service: a service that enables need fulfilment in such a way that it brings about a significant decrease in the materials component needed for the fulfilment.

Product system: a set of material products needed to jointly fulfil a user's needs.

Product: a tangible commodity, manufactured to be sold in large quantities. It is capable of falling onto your toes and of fulfilling a user's need.

Product-Service Cross: the lifecycle stage of a product where a service is provided

Profit pool: graphical representation of profits in an interconnected group of activities together fulfilling a need

Service: an activity (work) done for others with an economic value and often done on a commercial basis. In this project, we include work done by human beings as well as by automated systems.

Servuction: production chain for services

System: a collection of elements including their relations. Elements can be material or immaterial. The hierarchic level, system boundaries and relations are defined mainly as a result of the researcher's aim.

Unlinking or decoupling: achieving economic growth without an increase in environmental pressure

DECS: Douwe Egberts Coffee Systems International BV

EPS: Expanded PolyStyrene

HACCP: Hazard Analysis Critical Control Points

ICT: Information and Communication Technology

LCA: environmental Life Cycle Assessment

NGO: Non Governmental Organisations

ROI: Return On Investment or Return On Assets

RSI: Repetitive Strain Injury

SME: Small and Medium sized Enterprsise

TCA: Total Cost Accounting

USP: Unique Selling Point

Contacted Persons

During this project, we had contact with many people who all helped us in developing our ideas. Some persons we contact briefly, others were interviewed in a dedicated session. They were of great help to sharpen our thought and develop our ideas and concepts. Over here we like to thank these people for their inspiration, ideas, and other input. In the case of interviews, quotes will be given in the main text and references. We note explicitly that these people were not asked to agree with our ideas and concepts. Responsibility for the text restricts fully to the authors of the report.

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- W. Stahel, Life Cycle Institute
- W. van Zuilekom, Stybenex

Guidance Committee

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- A. Steentjes, Ministry EZ
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- R. Hartman, Syntens Amsterdam-Haarlem

Annexes

Annexe 1: How we have worked, into more detail

The field of Product Service systems and product-substitute services has only been partially explored. Isolated case studies, workshops and publications have resulted in islands of knowledge. This project means an important first step to expand this knowledge and to clarify the role of business and government. For this purpose, the researchers have split the project into three tasks that together constitute the inventory: the 'main research' task, the 'connecting with experts' task and the 'communication and building support' task.

'Main research' task

The main task has lead to a method for categorising and evaluating PS systems and contained the following elements:

1. Formulating the goal and defining the area of knowledge.
2. Making an inventory of cases (about 150) and selection of a limited set to work with in the project
3. Establishing evaluation criteria and an evaluation method for assessment of existing and new PS systems in terms of relevance and potential.
4. Evaluating selected cases on the basis of this method in order to test its usefulness and analysing the outcome of these case studies.
5. Indicating interesting areas of attention for future pilot projects.
6. Making suggestions regarding the role of the business community, the government and other players aimed at further expanding the knowledge of PS systems.

'Connecting with experts' task

During the preliminary study, it emerged that limited work is reported, only few articles exist. Meagre knowledge is shared among a handful of experts in Europe, Canada and the USA.
The expert line has enabled the researchers to spot the latest concepts, such as how to look at function fulfilment, examples, cases and environmental business strategies. The researchers have exchanged ideas with consulted expert (listed in the annex). Interviews have included environmental specialists, experts in the fields of product and service marketing, company's representatives responsible for PS systems development and business strategies. The selection comprised both Dutch and foreign specialists. Among these experts were the Confederation of Netherlands Industry and Employers (VNO-NCW) and the (Dutch) association of environmental product design, O2.

'Communication and building support' task

If a new subject is to receive attention from all walks of society, the foundation for this has to be laid within the fields of science, politics, business and social services. In order to gain support, the researchers have presented their first ideas at a O2 workshop and have published these in an article in O2 Magazine (August 1998): *Product service Combinations: next decade's promise?* This article focuses on the aims and preliminary results. A presentation of the project and its philosophy was given for Ecodesign specialists of the Dutch Syntens Network. A paper has been presented at a conference in Tsukuba (Japan) in 1998. In this paper, focus was put on the quantitative relationship between economic growth and environmental pressure. A fourth presentation was given for the Design Academy in the workshop *(Im)materials* and a final presentation for a group of policy makers of the Ministry of Environment (VROM) in The Netherlands.

Annexe 2: Analysis of PS Systems: What do target groups expect

In the assessment of PS systems involves actors with different roles and priorities. Below we will shortly comment the roles and issues of producers, consumers and authorities. Analysing PS systems should incorporate the key issues of all these actors.

Companies

Companies *create value*, as perceived by their clients. High-perceived value would be achieved by combining an optimal mix of products and services. Furthermore, the image of the product, service and their provider can have a major influence. The importance of investments in advertisement and communication should not be underestimated and should be regarded as standard element in the generation costs of PS systems.

For many consumer products, brand building and maintenance are key factors in the global competition. Investments in these may exceed costs of physical production and distribution for an increasing number of products, e.g. perfumes, cola, luxury clothing, cigarettes, sportswear, fine chocolates. PS systems can contribute to the quality of a brand and strengthen customer relationship.

High-perceived value should be created in a cost-effective way, as the companies have to balance revenues and costs. Company's principal goal is to make a high return on investment against an acceptable risk. The assessment of PS systems should enable producers to judge potential PS systems on their economic benefits (revenues for the sold value minus the costs), environmental consequences and market potential.

In the last decades, companies have come more aware of their environmental and social responsibilities. Often investment in these will be rewarding, as they contribute to a better image. Therefore, companies want to know what contribution they can expect from PS systems to improving environmental and social performance.

Making money is one, fitting in a company's strategy is a different issue. The method should pay attention to whether a new PS system would suit the business strategy and match the company's identity.

Furthermore, companies are important consuming parties themselves. The remarks in the section below apply for them too.

Consumers

Consumers *buy value*. They can choose from a wide range of offers for almost each function fulfilment. They will select what fits best to their personal needs, looking at price, quality, image, etc. They are not aware (or interested) of the company's bare costs. They perceive image, service and product as integral part of the value offer. Although they tend to feel accountable for the environmental impact of their behaviour, in general they are only willing to shift to sustainable patterns if this can be done comfortably and if costs are comparable. In Western countries, the number of 'green' customers is steadily growing. However, the acceptance of 'green' products differs from country to country, illustrating cultural and social value differences.

The assessment of PS systems should pay attention to the perceived value for the client, to the environmental load of the function fulfilment (or PS consumption) and to alternative behaviour patterns.

For a cup of coffee in a Grand Café people are willing to pay 1 or 2 Euro, since the quality of the coffee is good, it's served quickly and the place offers a good atmosphere. In a canteen at your work you will pay less than half these price, as atmosphere is lacking and quality is average (in most cases). On the other end of the scope, supermarkets use the price of coffee as a marketing tool to attract customers. In this case, making the cup of coffee is a do-it-yourself job.

An example that shows that consumers are willing to pay for fair and ecological products is ‘Max Havelaar’ coffee that is guaranteed to be produced by small scale coffee producer contributing to local economies. Premium payment for this coffee can be up to 25%. Market share is growing, illustrating that increasing interest and awareness of consumers.

Authorities

Authorities aim to find out which PS systems or sectors should get support in order to reach an economic growth against an absolute decrease of ecological pressure (unlinking economic growth and environmental load). Authorities want to use this information to stimulate companies and consumers towards more sustainable production and consumption.

The assessment of PS systems should be able to indicate environmental benefits on the level of function fulfilment, including the full lifecycle. In addition, the method should help identifying bottlenecks for introducing promising PS systems.

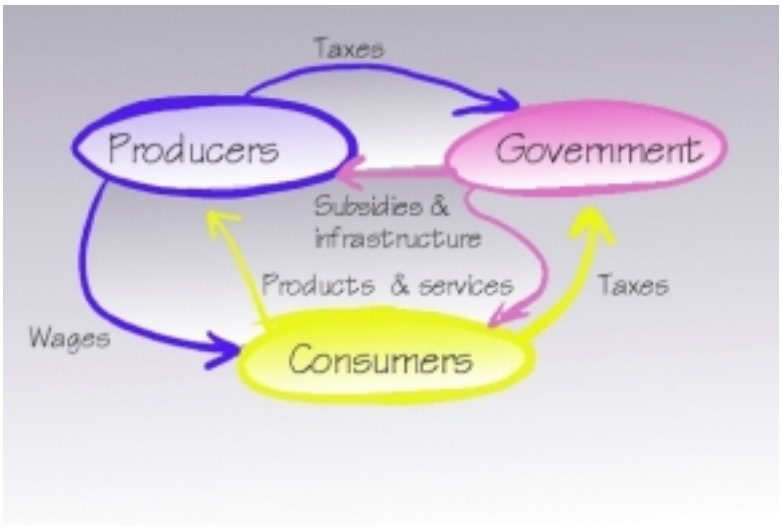
An important issue here is the macro-economic effect of systems change: the overall environmental and economic effects on national (or even world-wide) scale. How do the PS system changes influence the value created by a national society? Are shifts to be expected between economic sectors? What effect will a shift have on employment? The environmental gain of PS systems should not just be short-term benefits and preferably without any rebound effects.

Apart from this, governments are powerful consuming parties themselves. As a large purchasing party they can set examples as a niche marketing instrument (Jansen, 1998). The remarks made for customers do also apply for authorities.

Annexe 3: Reflection on economic growth

Although this report can't go too much into detail, we will reflect upon the basics of economic growth mechanisms. In our socio-economic system, economic growth is considered as an essential requirement for prosperity and social stability. But what is economic growth?

In very simplistic terms, economic growth is the result of ever-increasing product and money flows. But why do they increase and how are they inter-linked?
In short, the more value employees add, the more money they earn, the more products they buy, the more companies earn and the more wages they pay and value-adding investments they make. Economic growth means increasing the perceived value created in society, as expressed in financial terms. This results into a value increase of all products in circulation.



Additional to producer and consumer flows, there are flows between government and producers and between government and consumers. These flows are the steering mechanism of the economic development. Governments can encourage the development of environmentally efficient solutions in various ways, e.g. by incentives, policy, taxes, investments.

Although simplified, this version of the complex growth mechanism shows the essence of the problem: with the growth of our economy, more products come into circulation and usually this means more materials and energy is used. Thus the environmental load increases. Economic growth and increase in environmental load seem to be caught in an economy-ecology spiral that is difficult to break.

As one looks careful to this spiral, there appears a solution for unlinking environmental pressure from economic growth. Economic growth is linked to *perceived value creation* and not necessarily to material or product streams circulating in the economy. We have to find ways to increase the perceived value of all transactions without increasing the environmental load of products involved.

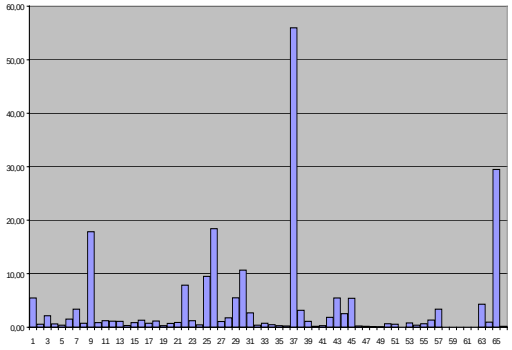
The solution could be to dematerialise economy. One strategy for this seems a shift from an economy based on the production of physical products to a services-based economy. This is the ‘working hypothesis’ of this project.

Annexe 4: Analysing the macro picture

In a macro perspective, we can raise the following question: *Can we analyse the environmental load per unit of economic value for different industrial sectors, and if so, are service sectors really outperforming industrial sectors?*

'First estimate' answers to this question can be achieved by the following approach:

- we consider energy consumption use as representative for the environmental load of a sector,
- and we make use of traditional sector information of the Dutch Statistics Office.



Energy consumption per value for each of the economic sectors in the Netherlands (Blonk et al, 1996).

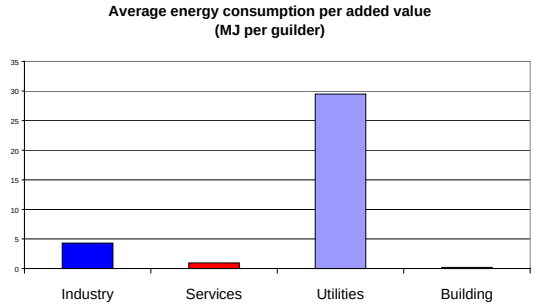
We've used data that specify the energy-use, the use of mineral resources, the creation of final waste and several hundreds of emissions per economic sector in The Netherlands. For the calculations we have used data (Blonk et. al. 1996) from the Dutch Emission Registry and the input/output table of the Dutch Central Statistics Office (CBS). We realise that selection of sector boundaries and the allocation of energy in- and outputs are not always made in a consistent way. Furthermore, production of services and material goods are highly connected in most sectors. The trends of the last decade, increasing complexity and burring of traditional sectors complicates the comparison of services and product oriented activities (also as result of a growing number of PS systems). Still we think the macro comparison of sectors is a good exercise to underpin the importance of our project.

First we have split up the Dutch economic sectors into four parts:

1. Industrial sectors, which mainly produce products (sector nrs 1-36)
2. Service-oriented sectors, that provide the majority of services (sector 41 and up)
3. Utility sector (gas, water, electricity)
4. Building and installation sector.

It is possible to compute the energy use per economic value creation in each sector.
In the table below, we have introduced for different categories to compare the industrial and the service sectors:

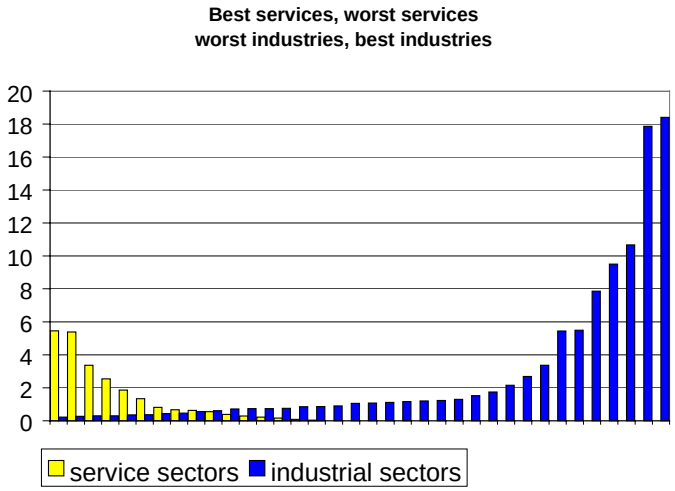
€ = 2.2 Dfl	**Industrial sectors**	**Service sectors**	**Utilities**	**Building and installation**
Value creation (x € 1000,0000,000)	147	177	9	30
Energy use (PJ)	1395	375	561	12
Energy use (MJ) Per Euro	**9.5**	**2.11**	**62**	**0.4**



The table (and resulting bar chart) show that on average, service sectors use over four times less energy per guilder compared to industrial sectors. This means that on average, growth of the service sectors on the expense of industrial sectors could give a considerable decrease of energy use, while the economy as a whole is growing. One can also observe that the energy use per guilder is the

highest for the utilities and that the ratio for the building and installation sector is low. Again we want to stress that this approach will give first-estimate results only.

Although the observation that *on average*, a shift from products towards services is favourable, the picture will become a bit less clear if we observe the variability between the sectors. Next pictures show the range in figures, while annex *Energy consumption per added value* gives this in order of the number of the economic sector.



This shows that the best industrial sector (i.c. clothing) scores over 20 times better than the worst service sector (repair of consumer goods (!)). One can also observe that the best utility sector (drinking water) performs about as well as the average service, while the worst utility (electricity production) performs 60 times worse. This high variability of results shows that, although on average services are to be preferred over products, there certainly are exceptions. This implies that we should analyse PS systems case by case.

An even more important notion is that the macro perspective does not cover the complete life cycle of products. Therefore, false conclusions can be drawn on the environmental performance of economic activities. To determine sound strategies towards sustainable production systems, we need to include the 'chain perspective'.

As mentioned above the service sector "Repair of consumer goods" is the worst performing economic service sector from the macro perspective. This may lead to the conclusion that the repair sector should not be stimulated to grow. At the same time however, we know that repairing durables is in many cases regarded as a positive activity from the lifecycle perspective, as this will lengthen the lifetime of products that embed quite some energy and material. From the lifecycle perspective one generally sees that, although energy is needed for repair, the life extension easily compensates for this. So despite the low economy/environment-value, one may conclude that the repair services should still be stimulated.

Our conclusions based on this sector comparison are twofold.

1. *It can be said that services sectors are in general better than industrial sectors.*
2. *Secondly, the differences within the sectors show that PS systems should be analysed case by case.*

Annexe 5: Estimating the economic merits of a PS system project within a company

At a company scale, the decision to develop a new PS system and to bring it to the marketplace has to be made in comparison with alternative investment options. The project has to be assessed according to the accepted set of corporate investment criteria. This is a onetime event, preceding the actual PS system project. The project period is defined as the development time plus the time the PS system is offered.

An economic analysis for the producer should therefore focus on costs (development, marketing, production and market-introduction costs) and revenues. All of these costs and revenues should be estimated in advance. In this paper, we will discuss three steps to make a thorough investment decision:

Step 1: selection of investment ranking method

There are many ways to define profit. In general, companies define profit in terms of accounting profit, return on investment or cash flow contribution. In our method we will regard profit in terms of return on invested capital as the default choice so the ROI is the first screening method. This method is very well suited for making decisions in highly innovative markets. For fine-tuning, it is best to proceed with the Net Present Value, which leads to results that are more reliable.

Step 2: determination of revenues

If expected revenues are unknown, it should be analysed what price consumers are currently willing to pay for the functionality provided by the PS system. Surplus payment can be expected in case of additional functionality.

In order to get reliable estimates for the revenues, consumer prices have to be corrected by factors such as: VAT, profit margins of selling points etceteras. The analysis of revenues does not need to be limited to the initial selling of a product or service. Often cross-selling occurs. For example, a printer manufacturer may earn more from selling service or toner cartridges than from the initial 'master product' sale. Thus, include all revenues in the product life chain. It is wise to list the revenues from different activities separately for a clear picture of the profit situation per activity. Profitability and turnover of the activities may differ enormously. The following table may be of help to list revenues. In this table revenues have to be filled in recalculated for a defined functional unit (e.g. 1000 product or service units sold). Future cash flows should be converted to their net present value.

Table for determination of revenues	
Income by selling the product/service (initial selling moment)	
Income by selling auxiliary products and services to support (core) functionality	
Income from replacement of auxiliary components	
Income from (standard) service contracts	
Income from lease or operational margins	
Income from ingredients	
Income from support, training	
Income by creating expanded functionality	
Income from additional products (e.g. additional features)	
Income from additional services	
Income by offering end-of-life solutions to consumers	
Payment for the end-of-life service	
Income from selling upgraded materials / components	
Income from selling secondary materials	
Other sources of income	
Subsidies	

Step 3: determination of costs

To estimate product service costs, Total Cost Accounting or Total Cost Assessment (TCA) can be used. TCA spans the economic life of a product or service. So, predictions for future

costs and assets are needed. In practice, Total Cost Accounting prolongs the time horizon with at least five years, compared to conventional methods. This is essential because a PS system often results in a system change. It takes time for both market and provider to adapt to this change. Even so, the prolonged time horizon shows future costs for end-of-life treatment like take-back and waste management.

Total Cost Accounting at the scale of individual company or co-operation companies is a two step process.

Step 3.1: Cost inventory

The first step is the inventory of costs. In addition to cost of capital initially invested in a project, it is suggested to include all standard exploitation cost as well.

Examples of categories that should be included:

- Costs of all parts of the product and service: prices of raw materials, components
- Costs of production and distribution: depreciation of buildings and production equipment, energy consumption, transportation and storage, and so on
- Costs of waste management, including the processing of production waste and (in case of extended producer responsibility) the end-of-life treatment of discarded products.

In Total Cost accounting direct costs for the producer are taken into account; allocated to the unit product or service. Within TCA, it is also possible to include indirect or less tangible costs, like liability risks and corporate PR-campaigns. In the revenues, benefits to the company value, such as grown client loyalty, could also be included (Brezet et al, 1996). In our method, we have chosen not to include these indirect or less tangible costs and revenues.

Table for cost inventory	
A. Costs to create the product service concept, initial costs	
Costs of research and development	
Labour	
Non-labour	
B. Costs to make the product service available	
Operation costs of production	
Labour	
Non-labour	
Costs of distribution	
Labour	
Non-labour	
Costs of PR, sale and marketing	
Production installation, realisation of (service) infrastructure	
Labour	
Non-labour	
C. Costs to support the use of the product service concept	
Labour	
Non-labour	
D. Costs for expanding functionality	
Labour	
Non-labour	
E. Costs for end-of-life	
Labour	
Non-labour	

Step 3.2: Cost allocation

In the allocation, costs are recalculated for the selected functional unit (e.g. 1000 units PS system). For this project, a profound table listing cost categories is drafted to assist the inventory. This table should contain a reflection of the costs made during the economic life cycle of the whole project.

Annexe 6: Lifecycle assessment

This annexe briefly explains the concept of environmental **L**ife **C**ycle **A**ssessment (**LCA**).

Life cycle assessment

Analysing a PS system can be done using a standard LCA or a LCA based method. However, it should be realised that some of the methodological bottlenecks of LCA will ask for extra carefulness when analysing PS systems. This we will explain below.

Measuring a mental construct

There is no single, easy-to-use and generally accepted environmental indicator (yet):

- *The* environment does not exist. The term 'environment' is a mental construct in which anyone can include almost anything that has to do with nature, health, future welfare, etceteras.
- Scientific knowledge of the processes in nature that keep our ecosystems healthy is very limited yet. Humankind is just beginning to grasp the basic relations.
- Our ability to analyse the exact interaction between product lifecycles and the environment is very limited too.

The most systematic way to analyse the interaction between a product and the environment are methods based on LCA methodology. This methodology is far from perfect and complete, however proves valuable in many cases. Moreover, there is no better alternative when dealing with environmental effects in a systematic way.

In an LCA, four steps are executed (Heijungs et al, 1992):

1. First, a model of the lifecycle of the product is constructed. It means analysing all product and service processes, from cradle to grave (as will be known from Ecodesign practice). Key word in defining the life cycle is Functional Unit: a standardised quantity of measurable function (or performance) fulfilled by both PS system and reference system. In case of PS systems it may not always be possible to find a reference system with the exact similar functional unit.

   For example a milk bottle that can be refilled ten times must be compared with 10 one-way milk cartons. A fluorescent lamp can be compared with a light bulb if we take into account the differences in lifetime and efficiency. The functional unit should be defined as a specific number of lumen over for instance a year.

2. In an LCA the emissions and resource extractions in each step in the life cycle are calculated as a second step. Usually the list of these emissions and resources is long and hard to interpret.

3. For this reason, the third step is to group them according to the effect they have. In this way we can calculate the greenhouse effect, the acidification, the depletion of fossil fuels and so on.

4. The fourth step is the most problematic: weighing these different scores. Who would tell us how to compare the gravity of a unit of greenhouse effect to a unit of carcinogenic substances? No perfect method is available.

In an LCA the fourth step is weighing several environmental impacts like the greenhouse effect and human toxicity. A range of solutions has been proposed to solve the weighing problem. We just name a few. For further reading is referred to Goedkoop (1995).

1. **Avoid weighing**. Disregard all effects, except one that is taken to be representative of all others. Examples are energy or exergy analysis and the “Ecologische Knappsack” method. The latter takes the amount of displaced material (including soil) as an indicator for all effects. These approaches are simple but very coarse, as they tend to overlook important effects.
2. **Panel methods**. A panel is asked to weigh the effects, using its knowledge or perception of problems. Simple but very sensitive to the way problems are presented and the panel composition.
3. **Prevention costs**. Analyse how much it would cost to prevent emissions from being released. The biggest problem in this approach is the site dependency. Filtering out one kg of mercury can be very expensive in one process, while it is quite easy or even profitable in another process.
4. **Societal costs**. One can analyse the cost incurred by society as a result of pollution. Two interesting projects are the Swedish EPS system and the ExterneE studies commissioned by the EC. Many assumptions have to be made before you can get weighing factors.
5. **The distance to target principle**. The basis for this method is the reduction that is needed to reach a sustainable level of effect. The problem is of course how to determine such a sustainable level. The Eco-indicator 95 method uses this approach in combination with the so-called damage approach. In stead of sustainable levels, also policy levels are used. In this case, the reduction targets set by politicians are used.
6. **Damage approach**. All available scientific information is used to calculate how much damage the effects cause to human health, ecosystem health and resources. Of course, when this is done we still have the problem of weighing these three types of damage. For this, a panel method is needed. Currently this method is being developed in the Eco-indicator 98 project.

For our project, we choose to eliminate the following weighing methods, due to several reasons:
1. “Ecologische Knapsack”, as this method is at best a method for land-use changes, but tells us nothing about human health, global warming, ozone etceteras.
2. Panel method. There is no generally accepted panel assessment.
3. Prevention costs. These methods are too site specific.
4. Societal costs. The EPS method is not very well accepted and the ExternE project has only produced data for the analysis of energy and transport systems.
5. Distance to target based on policy levels. These levels do not really express the seriousness of effects.
6. The damage approach is not operational yet.

Based on above elimination we will use several systems, depending on the application:
- Default method is the Eco-indicator 95 method (PRé, 1995). Although far from perfect, this approach is reasonably accepted and it includes most effects that are related to emissions. It does not include raw materials depletion nor the effect of land use caused by roads and for instance final waste.
- If this method overlooks or distorts aspects, or if no data are available, we will also use Energy, as an indicator for all effects, and in some cases the amount of waste. We will not try to weigh these aspects.

LCA's applied on PS systems

We will not describe LCA tools here, as there are many textbooks on this issue (a.o. Berg et al, 1994, Lindfors et al, 1995). Already we have stated that LCA can be applied on PS systems. Here, we will discuss some particular points of attention in these cases.

Functional unit, quality aspect
First, the result of a service can not always be easily expressed in terms of a functional unit. Many services provide rather soft elements, which are not easy to catch in a measurable functional unit. For instance: what if one is to compare fresh flowers to *very* fresh ones? This intangible element that is closely related to quality, should be solved on a case by case basis. If the effect of a service cannot be fully expressed in the functional unit, the discrepancies should be documented. The functional unit of the PS system should be matched by composing a reference system of existing products and services. Again discrepancies (incomplete match of functional units) should be listed.

> For example in the case of bus stops, the functional unit is providing shelter to waiting people, providing adequate information supply about departure, as well as offering advertisement space.

Functional unit, including changing behaviour patterns
Second, as we explained above, the matching process asks for a good understanding of the consumer's perspective. When we want to compare the situation before and after the introduction of the PS system, we must be sure that the functionality of both situations is comparable. The functionality of a situation can be described in many ways.

In LCA the functional unit must be described in such a way that it is relevant for the purpose of the study (ISO14040). This means we have a wide range of options to choose:
- In a narrow definition we compare transport systems on a basis of a certain transport distance. For instance, we compare the environmental effects of a passenger km of a car in comparison with a passenger km on a train.
- In a wider definition, we can compare the environmental effects of two persons travelling the same distance, using a car or public transport during a month. In this analysis, we would include trains, busses and perhaps bicycles.
- In a very wide definition, we could use the actual monthly transport activities of two persons, one car owner and one that does not own a car. In this analysis, we can se the differences in transport behaviour, in the use of public transport and bicycle etc.

The advantage of the narrow definition is that it is very well defined, but the value may be limited, as it is focused strictly on the technical aspects. It does not show that usually people have to make efforts to get to and from the station. The second, wider definition is more complete, but also more uncertain. It gives a better picture on the system, for instance if we want to compare options for commuters.
The third option is the definition that allows us to include the behavioural aspects, for instance that car owners usually drive more often. In case you make use of the wide definition you should strive for equal levels of consumer satisfaction in both situations of the comparison. Poor men without cars will travel less than rich men with Mercedes' will. However, as levels of satisfaction will differ, this is no basis for a fair comparison. It is best to search for situations of similar free choice.

The LCA methodology does not prescribe how wide the perspective should be. Each choice of perspective can be justified, when it is compatible with the purpose of the study and the information needed is available.

In case of the analysis of PS systems it is advised to choose a wide definition of functional unit. This is necessary, as the introduction of PS systems will have many and perhaps unexpected effects on other product systems. By choosing a functional unit that includes all or most of the systems to be affected we get a complete picture on the changes. Thus, in our analyses in chapter 5 we have chosen for a very wide definition of the functional unit.

It could even be decided to calculate the PS system both in a wide and a narrow definition to get an impression of the relative influence of behavioural changes on the outcome of the LCA comparison with the reference system.

Capital goods

Third, in most product-oriented LCA's, capital goods are left out. This is most of the times permitted as long as we judge short-term product improvements. In the case of PS systems we rather judge fundamental changes resulting from the introduction of PS system variants. It will affect infrastructure as well. Therefore capital goods should always be included in LCA's on PS systems. The Dutch CML-2 project, aiming to update the Dutch LCA guides, seems to draw the same conclusions on all LCA's (CML, to be published in 1999).

Human labour

Fourth, in most LCA's the effects of human labour are omitted. Of course, when we analyse services, we cannot ignore fully ignore the effects of human labour. To properly include them, we suggest the following guidelines:

- Transport of the service provider to the customer or transport of the customer to the service provider is probably a very important factor; therefore this has to be analysed.
- If the service provider uses a special room or office, the effects of heating, cooling and lighting has to be included.
- All sundries and tools used by the service provider are to be included as well.
- The person itself is regarded to be part of the natural system, so general effects caused by human life are left out.

Methodological details

Finally, the execution of an LCA may be hampered by methodological difficulties:

- PS systems are often difficult to separate from each other's. Therefore system boundaries and cut-off rules must be used.
- In many cases allocations are needed when a PS system is modelled.

However, these are not unique for PS systems.

In spite of the fact that these points ask for extra attention, the LCA methodology seems to be a valid and suitable systematic way to analyse PS systems in the lifecycle perspective. Consensus on how to deal with these problems is growing as the ISO process has already produced one standard and two draft standards (ISO 14040, ISO 14041 and coming soon: ISO 14042).