

# Clarifying the concept of product–service system

O.K. Mont

*The International Institute for Industrial Environmental Economics at Lund University, P.O. Box 196, Tegnersplatsen 4, SE-221 00 Lund, Sweden*

Received 29 January 2001; accepted 20 June 2001

---

## Abstract

A new trend of product–service systems (PSSs) that has the potential to minimise environmental impacts of both production and consumption is emerging. This article attempts to build a theoretical framework for PSS and serves as a background for identifying possible investment needs in studying them. There are three main uncertainties regarding the applicability and feasibility of PSSs: the readiness of companies to adopt them, the readiness of consumers to accept them, and their environmental implications. The main finding is that successful PSSs will require different societal infrastructure, human structures and organisational layouts in order to function in a sustainable manner. © 2002 Elsevier Science Ltd. All rights reserved.

**Keywords:** Product–service systems; Sustainability; Functional economy

---

## 1. Introduction

Sustainable production and consumption is an issue of current international concern. Many different approaches and concepts have been developed over the last decades to address environmental problems, such as cleaner production, cleaner technologies, waste minimisation and recycling approaches, eco-design and design for sustainability. However, a new strategy is called for in order to stimulate the change in current production and consumption patterns.

Rising levels of consumption by the rich and doubling of the world's population over the next 40–50 years would require a factor 4 increase in food production, a factor 6 increase in energy use and at least a factor of 8 of growth income [1]. It is estimated that by the middle of this century, resource productivity must have improved by a factor of 10.<sup>1</sup> This can be done by reducing the population, lowering the level of consumption or changing technology. The first option does not seem to be feasible in the short term. Decreasing consumption levels does not appear to be a simple option either because, on the one hand, people from industrialised

countries do not show any obvious willingness to minimise consumption and, on the other hand, there is a need to increase consumption levels in developing countries in order to provide basic amenities.

Recent thinking has focused on ‘dematerialising’ the economy — reducing the material flows in production and consumption; creating products and services that provide consumers with the same level of performance, but with an inherently lower environmental burden. Several authors have proposed the concept of product–services — providing utility to consumers through the use of services rather than products — as a possible example of a strategy for dematerialisation and a possible answer to the sustainability challenge. However, so far, little attention to this concept has been given at policy and operational levels.

The goal of this article is to contribute to building a theoretical background about the concept, and to stimulate debate about the sufficiency of existing efforts at academic and company levels.

## 2. Functional economy

At the turn of the millennium we are witnessing an escalation of service economies with society experiencing a transition from mass-production to flexible production. A service economy is defined as one in which

---

Tel: +46-46-222-0250; fax: +46-46-222-0230.

E-mail address: oksana.mont@iiee.lu.se.

<sup>1</sup> This means reductions of 90% compared to current levels.

more than half of the total labour force is employed by the service sector [2]. Approximately 70% of all workers in highly industrialised countries are employed in industries commonly thought of as services: communications, transportation, health care, education, wholesale and retail redistribution, and financial services. This new, more service-oriented model of manufacturing growth has key competitive factors such as the capability for continuous innovation, improved design and quality and customised goods, rather than the production of large volumes of standardised products.

What are the drivers of such structural change in our society? Some of the shifts in composition of output and employment depend, of course, on demographic factors. The environment itself has become a force for structural change. The industrial revolution, which shaped the development of the 20th century, worked by its own rules, at odds with those of the natural world. Resources were viewed as inexhaustible and the ecosystem as an infinite 'sink' for wastes. As the troubling symptoms of environmental decline have emerged, fundamental questions have been raised about the environmental profile and sustainability of existing industries. However, services have generally escaped this critical concern, being considered as less environmentally harmful.

Services have an increased share within the manufacturing industry [3]. The traditional boundary between manufacturing and services is becoming increasingly blurred. Of the employees that are working in traditional manufacturing industries, 65–75% perform service tasks ranging from production-related activities like research, logistics (transportation), planning, and maintenance, as well as product and process design, to the all-supportive services existing at any company (e.g. accounting, financing, law services and personnel functions).

The role of services in providing value is ever more important. Not long ago, most of a product's added value came from the production processes that transformed raw materials into products. Now, added value is created by technological improvements, intellectual property, product image and brand names, aesthetic design and styling; all non-material aspects of products. These help producers to differentiate and diversify their products to better respond to customers' demands — the so-called move from mass production to customised production or mass customisation. Therefore, there is an increased interest among manufacturers in adding value through the provision of services that extend the spectrum of their products. Thus 'services' extend into every part of the value chain.

The concept of a service society as a means of achieving sustainable development was proposed by Stahel [4]. He advocated the need to distinguish between industrial economy and service-oriented economy. Industrial economy places the central value on the exchange of the products that are consumed. The service economy, on the

contrary, recognises the value of utilisation, a performance driven orientation where the consumer pays for utilisation of the product. Therefore, the service economy is often referred to as functional economy, in which both product and technology are mere modes of providing function. The idea of functional economy rests upon the notion that function is the key to customers' satisfaction, not products per se. In a functional economy, consumers are buying mobility instead of cars, cleaning services instead of washing powders and movies instead of videocassettes [5], [6], [7]. A functional economy has the potential to be more environmentally benign because it addresses current levels of material/resource consumption, seeking options that may provide function/service to consumers without minimising their level of welfare. But realisation of this potential is not automatic.

In a functional economy, the role of the manufacturer is shifted towards provision of services [8]. Stahel notes that a functional economy "optimises the use (or function) of goods and services and thus, the management of existing wealth (goods, knowledge, and nature). The economic objective of the functional economy is to create the highest possible use value for the longest possible time while consuming as few material resources and energy as possible" [9]. In the functional economy, material products are treated as capital assets rather than as consumables, thus increasing value-added services to prolong the product's life and minimise loss of resources.

Present economies are mostly service economies saturated with products reinforced by services and some examples of alternative systems of product use. Empirical studies have indicated that even in industrialised countries with a high level of consumption, the penetration of new products and services is of more complementary nature rather than substitutional [10].

### 3. What is a product-service system?

The term "product-service systems" (PSSs) has been defined as "a marketable set of products and services capable of jointly fulfilling a user's need. The product/service ratio in this set can vary, either in terms of function fulfilment or economic value" [11]. Thus, more traditional material intensive ways of product utilisation are replaced by the possibility to fulfil consumers' needs through the provision of more dematerialised services, which are also often associated with changes in the ownership structure. Various approaches and trends towards the development of PSS can be outlined:

- the sale of the use of the product instead of the product itself [12];
- the change to a 'leasing society' [13];

- the substitution of goods by means of service machines [14];
- a repair-society instead of a throw-away society [15];
- the change in consumer attitudes from sales to service orientation.

Jansen and Vergragt have been working on the concept of sustainable product systems that crosses company boundaries and includes all stakeholders in the process [16]. Manzini proposes the idea of strategic design as a new approach for companies to engage in an increasingly ‘turbulent’ market. Strategic design focuses the design process on an integrated body of products, services and communications, as a model for companies to address changes in technology and social and consumer attitudes [17].<sup>2</sup>

The aforementioned efforts obviously provide only parts of the solution. Each of these approaches is a separate element of a PSS, with its own strong and weak sides and limitations and possibilities to minimise environmental impact. However, when one is to integrate them into a system, sub-optimisation might occur and overall environmental impact might not necessarily be reduced. Therefore, there is a need for a PSS, where the main focus on system solution is important. Understanding the difference between service and product is not relevant from an environmental point of view, since both generate environmental impacts. The challenge with the new approach lies in developing system solutions, where bits and pieces fit together, integrated into a system of people satisfaction. Such system-based solutions should facilitate the shift from separate systems of producing and consuming to a system, in which products, services, supporting infrastructure, and necessary networks are designed so that to provide a certain quality of life to consumers and, at the same time, minimise environmental impacts of the system.

Thus, a PSS should be defined as a system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models.

*For consumers*, PSSs mean a shift from buying products to buying services and system solutions that have a potential to minimise the environmental impacts of consumer needs and wants. This requires a higher level of customer involvement and education by producers.

*For producers and service providers*, PSSs mean a higher degree of responsibility for the product’s full life cycle, the early involvement of consumers in the design of the PSS, and design of the closed-loop system.

*For both consumers and producers*, PSSs might sometimes involve a change in property rights. In general, PSSs are likely to give more attention to the use phase of the product’s life cycle (consumer stage), than current product systems do.

A *paramount goal of product–service systems* should be to minimise the environmental impact of consumption by:

- closing material cycles;
- reducing consumption through alternative scenarios of product use;
- increasing overall resource productivity and dematerialisation of PSSs;
- providing system solutions seeking the perfection in integrating system elements along with improving resource and functional efficiency of each element.

The concept of a PSS in this interpretation is still theoretical. Examples of some PSS elements can be found in some companies, mainly driven by business and economic considerations, and therefore, environmental potential of such PSS elements has not been yet evaluated.

## 4. Why a product–service system?

### 4.1. Benefits

The PSS concept has the potential to bring about such changes in production and consumption patterns that might accelerate the shift towards more sustainable practices and societies. According to some authors, the concept might be promising for commercial companies, governments, and customers [18].

#### 4.1.1. For companies

Understanding PSSs provides the opportunity to see strategic new market opportunities, market trends and developments and potentially to stay competitive as patterns of production and consumption are transformed by environmental limits. The concept of a PSS facilitates innovation at a more than incremental level and has the potential to bring financial benefits.

Some companies are employing elements of PSSs as a natural extension of their existing offers to customers. Others see it as a survival strategy where the application of a PSS is seen as the centre of a new business plan. Usually such companies are forerunners and see the opportunity of being first on the market as a basis for survival.

There are different benefits to developing a PSS for manufacturing and service companies.

*For manufacturing companies* a service component adds/allows:

<sup>2</sup> See also the development of this idea in the handbook of the Masters of Strategic Design, Politecnico di Milano ([www.mip.polimi.it/mds](http://www.mip.polimi.it/mds)).

- To attach additional value to a product, for example, financial schemes or refurbishing or upgrading.
- To base a growth strategy on innovation in a mature industry.
- To improve relationships with consumers because of increased contact and flow of information about consumers' preferences.
- To improve the total value for the customer because of increased servicing and service components, which include activities and schemes that make the existing product last longer, extend its function (upgrading and refurbishment), and make the product and its materials useful after finishing its life cycle (recycling and reuse of parts or entire product).
- To anticipate the implications of future take-back legislation, and might have the potential to turn them into a competitive advantage.

*For service companies, product components:*

- Extend and diversify the service.
- Safeguard market share by bringing the service component into the offer that is not so easy to copy.
- Facilitate communicating product–service information, because it is easier to convey information about more tangible products than about intangible services [19].
- Safeguard a certain level of quality that is difficult to change (product quality).

#### 4.1.2. *For government and society*

Understanding PSSs can therefore, help to formulate policies that promote sustainable patterns of consumption and sustainable lifestyles. PSSs have the potential to offer a new way of understanding and influencing stakeholder relationships and viewing product networks, which may facilitate development of more efficient policies.

At the same time, it is expected that the promotion of added services or substitutes of products and alternative schemes of product–service use can assist in the creation of new jobs. The functional economy might be more labour-intensive than an economy based on mass production and throwaway patterns of consumption. More jobs per unit of material product might be created because of such labour-intensive services as take back systems, repair, refurbishment, or disassembly. With time, however, these services might become large-scale operations that will require automatisisation, and which may decrease employment.

#### 4.1.3. *For consumers*

Consumers benefit from a PSS because they receive greater diversity of choices in the market; maintenance and repair services; various payment schemes; and the

prospect of different schemes of product use that suit them best in terms of ownership responsibilities. Consumers get added value through more customised offers of a higher quality (from the product/service per se and the delivery/provision). The service component, being flexible by nature, induces new combinations of products and services, better able to respond to changing needs and conditions. Consumers may be relieved from the responsibility for a product that stays under ownership of a producer for its entire life span. Through PSSs, consumers may more easily learn about environmental features of products and how they can contribute to minimising the environmental impacts of consumption.

#### 4.1.4. *For the environment*

A PSS has the potential to decrease the total amount of products by introducing alternative scenarios of product use, for example, sharing/renting/leasing schemes to consumers, however, not affecting design of the products. With PSS, producers become more responsible for their product–services in case material cycles are closed. Producers are encouraged to take back their products, upgrade and refurbish them and use them again. In the end, less waste is incinerated or landfilled.

The PSS approach changes the price cost systems of the present economy because “the costs of production are only a very small part of the costs involved in making a product available to the customer” [20]; consumers do not pay for material goods but for intangible services. This can amplify the technical development of dematerialisation, which is already an on-going process [21].

#### 4.2. *Drivers*

The drivers for the development of PSS have largely been canvassed in previous sections. PSSs more appropriately respond to the demands of today than existing systems of mass production. This is an evolution of the economic transition away from standardised and mass production towards flexibility, mass-customisation and markets driven by quality and added value rather than cost. Core competencies, rather than physical assets, increasingly define leadership of companies on the market.

Improved competitiveness through improved environmental performance is also named among the drivers of the shift from selling products to provision of services. Others include legislative threats, particularly relating to extended producer responsibilities (EPR), and consumers behaviour/demands [22].

There are certain conditions under which development and application of PSS might be profitable [18]. First of all, PSS will be profitable if the costs of use and disposal phases (and the collection of end-of-life products) are internalised. The development of a proper PSS with an efficient take back system could stimulate consumers to

return products. The second condition is if the product, at the disposal stage, has a high market value. The third condition of a profitable PSS is when an alternative scenario of product use generates additional profit (or reduces a current cost). For example, the legislation requires that a producer of a chemical takes care of her/his chemicals after they are sold. In this case, product ‘maintenance’, becomes an additional cost. If the producer, instead of selling the chemical, provides its function, it becomes a profit generator and a stimulus to minimise the consumption of the chemical, which is beneficial for the consumer as well. Thus, it appears that one of the most important external drivers for a company is supplier development.

## 5. Product–service system elements

The study of literature on product–services and eco-efficient services, and communication with experts and researchers working with PSS revealed a clear lack of common understanding of PSS elements. The following figure provides a list of the main PSS elements, which may provide a common term of reference for studying and designing PSSs (Fig. 1).

1. A PSS may consist of products, services, or various combinations of them. Products substituted by services are largely an ideal category without many practical or consistent examples, because any service, even nonmaterial per se, requires material or energy inputs.
2. Services, at the point of sale, comprise personal assistance in shops, financial schemes provided to customers, explanations about product use and, of course, marketing.
3. Different concepts of product use consist of two categories: use oriented, where product utility is extracted by the user, and result oriented, where product utility is extracted by the utility provider for the user.
4. Maintenance services include servicing of products

with the goal of prolonging product life cycle, comprising maintenance and upgrading.

5. Revalorisation services include offers that aim at closing the product material cycle by taking products back, secondary utilisation of usable parts in new products and recycling of materials if reuse is not feasible.

Thus, PSSs consist of a combination of eco-designed products, reinforced by designed services at different stages of a product’s life cycle, and comprising different concepts of the product use (both use and result oriented, depending on the logistics and ultimately environmental profile of the PSS), closely involving final consumers and actors in the chain and beyond.

## 6. Characteristics of product–service systems

### 6.1. The role of producers

The successful development of a PSS requires that manufacturers and service providers extend their involvement and responsibility to phases in the life cycle, which are usually outside the traditional buyer–seller relationship, such as take back, recovery, reuse and refurbishment and remanufacturing. Usual responsibilities for products are extended through the additional or deepened responsibility for service, including the responsibility for proper organisation of take back arrangements and systems for reuse, remanufacturing and recycling and for educating consumers about efficient product use. Reduced material flow also requires a stronger co-operation with suppliers. Information and economic benefits from the service provision stage (consumer stage) can be easily transferred to the manufacturing, development/design stage, thus the entire system becomes more responsive to changing market parameters and is probably inherently more likely to stimulate innovation.

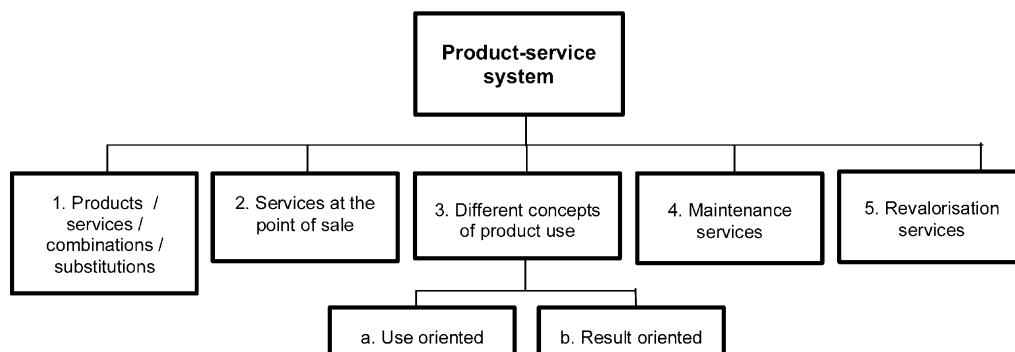


Fig. 1. Classification of a product–service system.

## 6.2. The role of consumers

The relationship between the company and a customer plays a key role if the PSSs are to be designed and run effectively. Some proactive companies have started working more closely with their customers, who then have depended on them for many types of information, including environmental. In turn, these companies often have early insights into consumer tastes, preferences and regional buying habits. Thus, such companies play a critical role in both satisfying and creating consumer preferences for goods and services, including their environmental dimensions.

## 6.3. Organisational basis for product–service systems

Companies that are pursuing the concept of PSSs will need to change traditional structures, regardless of whether they are manufacturing or service organisations. Close co-operation with consumers extends the role of the marketing division. Information management will play an increasing role in improving organisational efficiency and customer communication. As product–service development occurs during interaction with the consumer, the structure of decision making is likely to be more decentralised.

The extended involvement of the organisation with other companies leads to intra-organisational changes that include performance indicators and the demand for human capital. These intra-organisational changes modify the relationships between the business functions within the company. Inter-organisational changes, such as a closer interaction with other actors in the product–service chain and outsourcing, may create the demand for intermediates.

New networks may need to be established in order to develop PSSs. These can be research networks that can investigate market changes and consumer preferences; information-sharing networks developed to share information that is relevant for entire product chains or the industry sector; or regional or sectoral networks that bring together industries located in the same region or representing the same sector to exchange the best practices, set levels of performance or exchange by-products or wastes.

## 6.4. Design particularities

There are few examples of design projects/attempts where an entire PSS is re-designed. The design methodology of the entire PSS will probably differ from the product design methodology due to a following number of reasons:

- Designing a PSS requires close integration of all actors within the life cycle of a product–service. Tight

integration, especially between the service and manufacturing organisations, is more likely to permit the clear ‘transmission’ of the economic incentives, allowing service activities to drive manufacturing or design changes.

- Schemes for taking back products at the end of their life, as well as all necessary arrangements with business partners, should be focused on ensuring maximum closing of the product flow and reduction of transport distances.
- Alternative scenarios of product use could be analysed and the range of these scenarios may be presented to the consumer, providing information on economic and environmental features of the PSS.
- Marketing strategies could be developed in ways that teach and promote an environmentally and socially more acceptable way of function fulfilment. They could include communication campaigns during which the producer would provide consumers with information and presentations about utilising her/his products most efficiently.
- Alternative scenarios of servicing the products could also be given at the point of sale to ensure the proper product exploitation during the use phase.

## 6.5. Environmental profile

Services are not necessarily less environmentally problematic than manufacturing industries, but in an economy in which they dominate and serve as some of the most dynamic drivers of change, it is important to examine them directly in search for opportunities to halt environmental degradation and to improve their environmental quality. PSSs are focused on addressing the use phase to reduce the total environmental burden of consumption. However, there is a need to consider carefully the impact of other phases such as production and post-production activities.

What are the possibilities to reduce environmental burdens with a PSS? The following can be deduced from the discussion so far:

- The environmental impacts of the use phase come from the efficiency of each unit of function delivered and the total amount of a delivered service. The design of PSSs can provide an incentive to manufacturers to design products that are more efficient in their use phase only when the producer will be paying for the environmental effects and resource consumption during this phase, that is, when the conditions internalise use-related environmental costs.
- A number of ecological advantages can arise from the sale of services. For instance, it may encourage the producers’ interest in the reuse and increase of the recyclability rate of products. The services could

include new, used and refurbished products. Ideally, this could lead to completely closed product cycles under the responsibility of the manufacturers.

- The substitution of energy and materials with efficient services may influence overall resource consumption. Increasing the intensity of use, if products are shared or used jointly, may potentially minimise the total number of products and the capacity for use can be more fully realised resulting in greater resource efficiency and less impact on the environment.
- If the operation of the product–service is a cost for the company that has internalised it, the producer might be interested in providing maintenance that helps to extend product life and thus reduce the quantity of the product required for delivering the service that is less product per unit of services and thus less environmental burden.

In order to assess the environmental performance of PSSs, there is a need to develop criteria that could reflect the life span of a product, efficiency of resource consumption, closed cycle efficiency and potential for improvement.

## 7. Barriers for product–service systems

The concept of PSSs is still being developed, but has already been suggested as a possible scenario of moving towards more sustainable production and consumption systems. It, therefore, is important to examine all conceivable barriers to its development, application and continuous betterment.

- It may be difficult to develop scenarios of alternative product use because they often include elements that are situated between production and consumption (sales) and several stakeholders may need to be involved in designing both the product and the service system.
- A social system or infrastructure that would accept or support the suggested product–service scenario should be found. If such a system does not exist, a completely new infrastructure or network might need to be designed that can support the environmentally benign performance of the new product.
- PSSs, require from their producer, close co-operation with suppliers and service producers or final consumers. While relationships with suppliers are addressed by ISO 14000-series standards and environmentally conscious purchasing practices, downstream practices are addressed by EPR and Product Stewardship concepts. Integrated Chain Management specifically addresses the issue of involving several actors in order to improve the environmental performance of products. However, problems associa-

ted with ICM are also going to be relevant for PSSs due to similar value chain basis, that is extended in PSSs into a value network. These problems include trade-offs between co-operation and internal environmental management; the problem of choosing wrong actors who do not have the power to change or influence events; information sharing and transparency and barriers from material flows crossing borders and a variety of regulatory frameworks in different countries.

- Although, ideally, ownerless consumption offers many advantages and hopes, it has its own problems. For instance, studies conducted reveal that the multiple use does not automatically lead to less impact on the environment [23]. The environmental impact depends, to a large extent, on the circumstances, schemes and conditions of use. Leasing, for example, can promote use of products which otherwise would not be affordable for customers. Without the option of leasing, the purchase could have to be postponed to a later date. On the other hand, leasing can facilitate the return of old appliances since the duration of use is monitored and they are returned after the lease has run out, if the purchase option is not executed. This could strengthen the manufacturers' interest in their own products and could improve the economic conditions for a closed cycle economy.
- Changing systems and sources of gaining profit could deter producers from employing this concept. Where point-of-sale becomes a point-of-service that operates over an extended period of time, traditional incentives can fail to reflect the real drivers of profit for the firm. A particular problem is the changeover from short-term profit realisation at the point-of-sale to medium- and long-term amortisation periods at the point-of-service. Moreover, another characteristic of PSSs that affects the usual ways of gaining profits is the possibility of raising revenue and getting profit not through sales but through efficiency provision (energy services; Demand Side Management and Chemical Management Services).
- The resistance of companies to extend involvement with a product beyond point-of-sale and historical practice has been identified as a major barrier to increased manufacturer responsibility for environmental impacts of products [24]. The extended involvement leads to intra-organisational and inter-organisational changes, such as closer interaction with other actors in the product–service chain. This happens partially due to inertia and fear of innovations.
- The reorientation of companies towards PSSs requires a fundamental shift in corporate culture and market engagement, which, in turn, requires time and resources to facilitate the shift. Changing the orientation of the company from product to service sale means also changing the traditional marketing con-

cepts. This is often met with psychological barriers in companies.

- It is quite difficult to trace the shift in service or manufacturing industries because of differences in how services are reported in national and international statistics.<sup>3</sup> For example, in manufacturing companies, human resources, canteens and medical care centres for workers may be included as services or as manufacturing departments.
- Adding environmental considerations to the product development cycle is often seen as lengthening the time to market. This is even more so if the entire PSS should be designed with criteria of environmental efficiency in mind.
- Consumers might not be very enthusiastic about ownerless consumption. Numerous examples of practical applications of product–service ideas in the commercial sector did not facilitate operationalisation in the private market [9]. The successful models such as car sharing are still limited to small market niches.
- Customers' demands and purchasing behaviour appears to be potentially more complicated than expected. The assumptions that the customer is more interested in use rather than the ownership [25] or is looking for the use rather than the product itself does not represent current reality.

## 8. Conclusions

An important conclusion is that there are many examples that illustrate parts of the solution (eco-design, optimisation of distribution, product customisation, added services, take-back systems, remanufacturing, and recycling), but there are few examples of complete PSSs that are being designed on a life cycle basis in companies. The companies often lack a system approach. Another reason for such a limited application of PSSs in companies is the fact that the PSS is a new area and even at the academic level PSSs have not yet been studied and shaped for practical applications. Therefore, a number of uncertainties concerning the characteristics of the PSSs can be highlighted. These uncertainties can be combined into three main categories:

- Readiness to adopt the PSSs into a company's strategic decisions. The shift from selling products to providing PSS entails substantial changes in the companies' structure and organisational frameworks, production and marketing strategies, as well as their

relationships with stakeholders. Few studies have evaluated the profitability of PSSs for companies, although present economic difficulties within some companies serve as a counter-argument to the outcome of the evaluation.

- Readiness to accept the PSSs by consumers. Little research has been conducted on evaluating the competitiveness of PSSs and their profitability for consumers.
- Environmental characteristics of PSSs are also not yet studied. A number of studies evaluated the environmental features of particular stages and activities, such as remanufacturing and take back as favourable. On the other hand, other studies showed that environmental characteristics of, for example, eco-services should be accounted for carefully, because they are not always preferable in comparison to products.

The results of the study provide a background for setting future research directions. There is a need to further explore the design side of PSSs and to develop a methodological basis for their development, practical implementation and evaluation of economic, environmental and social consequences.

## References

- [1] Factor 10 Club. Statement to government and business leaders, 1997. <http://www.baltic-region.net/science/factor10.htm> 1999-11-20.
- [2] Fuchs, VR. The service economy. National Bureau of Economic Research, 1968. p. 1.
- [3] Ayres RU. Technological progress: a proposed measure. *Technol Forecast Social Change* 1998;59:213–33.
- [4] Stahel WR. The limits to certainty: facing risks in the new service economy. Dordrecht: Kluwer Academic Publishers, 1989.
- [5] Friend G. The end of ownership? Leasing, licensing, and environmental quality. *New Bottom Line* 1994;3(11).
- [6] Pantzar M, Raijas A, Heiskanen E. Green consumers? Greening consumption? The Instruments to Promote Sustainable Patterns of Consumption and Production. Seminar, Stockholm, 1994.
- [7] Popov F, DeSimone D. Eco-efficiency — the business link to sustainable development. Cambridge (MA): The MIT Press, 1997.
- [8] Ayres RU. Toward a zero-emissions economy. *Environ Sci Technol* 1998;1.
- [9] Stahel WR. The functional economy: cultural and organisational change. From the industrial green game: implications for environmental design and management. Washington (DC): National Academy Press, 1997.
- [10] Fioruzzi M. Dematerialization and service economy: how good is it? 1996. [http://www.cyen.com/green\\_value/paper1.htm](http://www.cyen.com/green_value/paper1.htm) 1998-08-20
- [11] Goedkoop MJ, van Halen CJG, te Riele HRM, Rommens, PJM. Product service systems, ecological and economic basis. PricewaterhouseCoopers N.V. / Pi!MC, Storm C.S., Pre consultants, 1999.
- [12] Stahel WR. Langlebigkeit und Materialrecycling — Strategien zur Vermeidung von Abfällen im Bereich der Produkte. Essen: Vulkan Verlag, 1991.

<sup>3</sup> This problem was recognised and discussed at the World Service Congress'99 with Ms Gunnel Mohme, the Head of the Service Business Unit at Svenska Industriförbundet.



- [13] Braungart M. Die Leasinggesellschaft — unverkäufliche Produkte, Gebrauchsgüter, Verbrauchsgüter. In: B.A.U.M., editor. *Mit Umweltschutz zum Gewinn für die Wirtschaft und die Umwelt. Kongreß Reader*. Hamburg, 1991. p. 109–22.
- [14] Schmidt-Bleek F. *Wieviele Umwelt braucht der Mensch? MIPS — Das Mass für ökologisches Wirtschaften*. Boston: Birkhäuser Verlag, 1994.
- [15] Blau E, Wei N, Wenisch A. *Die Reparaturgesellschaft — das Ende der Wegwerfkultur*. Wien, 1997.
- [16] Jansen L, Vergragt P. *Sustainable technology development vision (Key to sustainable prosperity)*. The Hague, 1997.
- [17] Manzini E. Different scenarios of products and services combinations. Presented at the Conference ‘Challenges of Sustainable Development’, Organised by the International Network of Engineers and Scientists (INES) Workshop ‘Industry and Sustainability: Pioneer Industries on Sustainable Services’. Amsterdam, 1996.
- [18] White, AL, Stoughton, M, Feng L. *Servicizing: the quiet transition to extended product responsibility*. Report Submitted to US Environmental Protection Agency, Office of Solid Waste, 1999.
- [19] This was shown in Schneider Å. *Environmental declarations as a communication tool for IT-services: the case of Telia*. Masters thesis. IIIEE, Lund (Sweden), 1999.
- [20] Giarini O, Liedtke P. The employment dilemma and the future of work. Alternative title: working in the new (service) economy. The final draft of the report to The Club of Rome, 1998:140.
- [21] Hinterberger F, Luks F. Dematerialization, employment and competitiveness in a globalized economy. Wuppertal Institute for Climate, Environment and Energy. Paper prepared for the plenary session of the Fifth Biennial Conference of the International Society for Ecological Economics (ISEE) ‘Beyond Growth: Policies and Institutions for Sustainability’, 1999:9.
- [22] Goedkoop MJ, van Halen CJG, te Riele HRM, Rommens PJM. *Product service systems, ecological and economic basis*. The Report No. 1999/36 submitted to Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 1999:22–5.
- [23] Krutwagen B. for van Kampen M. *Eco-services for sustainable development*. Paper presented at the IIIEE Network — The First Global Experience Sharing Conference, 1999 Sept 24–26.
- [24] Stoughton M, Shapiro K, Feng L, Reiskin E. *The business case for EPR: a feasibility study for developing a decision-support tool*. Boston (MA): Tellus Institute, 1998.
- [25] Braungart M, Engelfried J. *The intelligent product system*. Bull EPEA, Hamburg 1993:36.