

Product Service Systems beyond Sustainable Products

Case Study of Prefabricated Unit House Reuse System

Myung-Joo Kang and Robert Wimmer

*GrAT (Center for Appropriate Technology), Vienna University of Technology
Austria, kang@grat.at, rw@grat.at*

Abstract: Product Service Systems (PSS) are system solutions that directly fulfil client demands with a combined set of products and services. The PSS strategy allows companies to gain profits by providing highly customised and need-oriented system solutions. Thus, producing and selling greater volume of new products is not a major concern of PSS solution providers. By decoupling economic value creation and material consumption, as well as being a source of new employment for manpower-based services, the PSS strategy is one of the most advanced sustainable development approaches. This paper aims to help designers to understand the PSS concept and its potential for sustainable development and introduces a PSS development project conducted in collaboration with a prefabricated-housing company. As one of the main results of the project, the importance of emotional and socio-symbolic values in PSS design and marketing is highlighted as a critical factor for customer acceptance.

Key words: *Product Service Systems (PSS), sustainable development, prefabricated unit house, emotion.*

1. Introduction to Product Service Systems (PSS)

Material prosperity was the priority demand in the previous industrial age, and production and sales of products were therefore the key virtue of companies. Our economic growth has been strongly rooted in volume of product sales for decades. Many entrepreneurs believed that they could sustain their business by developing new products, increasing production and sales volume, and globalising the market. In the current post-industrial age, however, the range of consumer demands has expanded far beyond material goods. As Jensen predicted, “the purely material function gradually becomes trivial, taken for granted, and a by-product” [6]. Other values such as information, knowledge, experience, time-saving, convenience, and comfort are now crucial in the market. Furthermore, the material-oriented strategy is facing environmental and social consequences. Severe pollution, waste accumulation, and the gap between the rich and the poor are already evident.

As a response, sustainability has been discussed as one of the global matters of interests since the late 1990s, and more obviously in the new millennium. Many enterprises are seeking sustainable business strategies that reflect the growing concerns on climate change, resource scarcity, and social responsibility. Environmental policies such as end-of-pipe management, cleaner production, and eco-design of products have been successively implemented by industries. These approaches have achieved economic savings and lowered environmental burdens. Yet, authors agree that incremental technological innovation and eco-designed products of companies

cannot reduce the environmental impact by a factor higher than 2 [18]. In addition to technological measures, cultural and institutional innovations need to be combined to achieve this goal [12,20]. Such fundamental changes in production and consumption call for solutions more radical than product improvement. This paper puts emphasis on Product Service Systems (PSS) as an even more advanced strategy than the above-mentioned production-oriented sustainable development approaches.

PSS are known as system solutions that directly fulfil client demands with a combination of products and services. If these system solutions are compared with conventional products sales offers, substantial differences can be found. In the case of the typical product sales model, producing and selling products is the primary method to meet client demands, regardless of the type of actual demands. Consumption of these material-based solutions occurs after the sales point. For a customer who wants to hang a frame on a wall, for example, a product sales model produces hammers and nails and sells them. There is a gap between the solution (i.e. hammers and nails) and the desired result (i.e. a frame hung on a wall). In a PSS solution, the main strategy is to provide a customer with an access to products and to sell their functions instead of the ownership. The PSS solution provider hangs the frame on the wall according to the customer's specific preference. Hammers and nails are included as product elements of the package solution. The more complex the demanded product or solution appears (e.g. a house), the more important and efficient it is to provide services in addition to the product itself.

2. Potential of PSS for Sustainable Development in Post-Industrial Age

2.1 Decoupling of Material Consumption and Value Creation

Most PSS solutions, as illustrated above, do not necessarily produce and sell a new product. Instead, an efficient and effective combination of existing products, labour, and knowledge allows the company to gain profit and save materials, while serving client demands equally well as, or even better than, a product sales model. Due to the increased utilisation of non-material elements, PSS tend to be more sustainable than conventional product sales models. The shift from traditional product sale models to service-oriented system solutions is often envisaged as in the following figure [3,19]. The current product sales system that creates less economic values with larger environmental impacts is reoriented to the new system where values are created from less consumption of natural resources. PSS are a major driving force for this reorientation and can achieve sustainable development beyond factor of 2 [1,18].

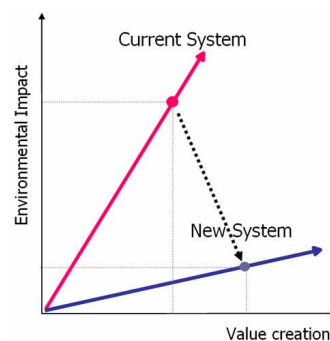


Figure 1: Decoupling value creation and environmental impact (adapted from [19])

2.2 Producers' Responsibility by Retaining Property Rights

Another factor differentiating PSS from typical product sales is property rights. In many PSS cases, products remain the provider's property. For example, in chemical leasing systems, the solution provider retains the ownership of chemical substances during use and reprocessing. Even if physical locations of the substances change over their lifecycle, these substances are perceptually only *leased* out to the users [5]. Retaining the property rights on the provider's side can radically alter environmental and economic performances compared to the traditional transaction of property rights in product sales. As far as environmental aspects are concerned, the right to access material resources is bound to the solution provider, as is the responsibility for handling material and product resources. This makes it more likely that resources circulate. In economic terms, a new profit generation model (e.g. regular income over a longer period) is expected. In the chemical leasing example, the provider charges customers monthly or yearly fees for handling chemical substances, and thus, can earn greater profit while exploiting a smaller amount of chemical substances. These environmental and economic features are viable for PSS models in other industries as well.

In the traditional product trade processes, the main cut-off signal in tracking lifecycle performances of a product occurs at the selling point when ownership shifts to the consumer [21]. Thereafter, the product's environmental performance is hardly predictable. The overall lifecycle performance, however, is critically determined by the efficiency of product use, and take-back, reuse, refurbishment, recycling and safe disposal are highly important for resource circulation. Thus, beyond the efforts to increase resource productivity within design and production procedures, particular measures need to be provided during the use and post-use phases [1]. By retaining the property rights of a product, PSS providers can influence eco-efficiency after the sales point. For instance, the chemical leasing service enables optimised use and treatment of the chemical substances, and product rental services allow intensive use of products and timely maintenance, upgrade, and repair prolong the product lifetime. Planning and optimising the real lifecycle performance requires looking at the overall system beyond product sales.

2.3 Creation of Employment

PSS strategies can create more employment in industries. According to the generic nature of a service, PSS mostly involve manpower. Mont noted the labour-intensiveness of PSS (such as maintaining, updating, and repairing products) compared with manufacturing new products, and highlighted the community benefits associated with increased employment [9]. Even with automatic or digitalised service operation cases (e.g. online library searching, vending machines, etc.), the human efforts behind the function (e.g. software development and maintenance, refilling of consumables, etc.) are considered to be an essential labour element in the overall system offer.

In contrast to product sales, many PSS services require human intelligence and skill-based services. A significant difference between the product and the service markets is that services are more difficult to import¹. Stoughton and his co-authors shed light on the general social performance of PSS with regard to their competitive advantages in domestic markets against foreign competitors based on 'local knowledge and capability'. PSS can

¹ One might think of labour import cases (i.e. foreign workers) or services that require specific foreign capabilities (e.g. language lessons, gourmet services). However, for a high quality interface with customers in most situations, local staffs have better chances because they are more familiar with regional attributes such as language, traditions, common sense, and culture.

be an intelligent policy to encourage regional economies that face strong price competition in the product market with foreign nations, where the labour costs can be comparatively low [16].

3. Methodologies and Applications

3.1 Methodological Support for Sustainable PSS Design

From an entrepreneur's perspective, shifting a business focus from selling products to providing combined package solutions can be a significant challenge. The longer the organisation has concentrated on product manufacturing and sales, the more difficult the change may appear. These enterprises need to be guided step by step to learn how to come up with PSS solutions while avoiding errors. To support the transition, and especially to make the new solutions more sustainable than those available today, many supportive methodologies for PSS development have been suggested.

Most of the methodological research for PSS has been conducted in Europe within the last ten years. Particularly under the 5th European Commission research framework, "Competitive and Sustainable Growth Programme", a conceptual framework was constructed, and the potential contribution of PSS for sustainable development was analysed. "Methodology for PSS innovation (MEPSS)" was one of the key results from the programme, which was elaborated to assist companies in designing clean, clever, and competitive PSS strategies. During the MEPSS project, various methodologies in different fields of expertise were collated and assembled, yielding a handbook and a web tool (www.mepss.nl).

3.2 Industrial Application

Despite available methodological support for systematic PSS design, industrial applications remained rare. The reasons for the lack of enthusiasm of the business world were analysed to be: insufficient or false understanding of the PSS concept; lack of success stories motivating more development in industries; and difficulties in directing consumer behaviour towards PSS solutions. To overcome these hurdles, the authors have conducted a number of PSS development and implementation projects since 2006. The following "Unit House Reuse System" is one of the projects, and it represents industrial cases demonstrating the sustainability potential of PSS, especially for environmental and economic benefits. At the same time, the project functions as an opportunity to verify a research hypothesis regarding market competitiveness of PSS solutions (see below in 4.4).

MEPSS was chosen as the main methodology for the following PSS development projects due to its profound guidance for sustainability considerations and complete development processes from preparation up to market implementation. The role of this method was to design the PSS more systematically and to sufficiently consider all three domains for sustainable development – environmental, social, and economic.

4. Case Study

4.1 Prefabricated Unit House Reuse System

Sekisui Chemical, as one of the market leaders of the prefabricated-housing industry, produces a living space on a production line in a plant under strict quality control, like cars are produced. More than 80% of an individual house is produced in the plant. The business was started in 1970, and one of the main focal points was on mass production and mass sales of houses. At that time, Japan was undergoing a period of high economic growth, in which both increased quantity and improved quality of housing were in demand. The mass-production system

for housing perfectly matched these needs [15]. In the new era, however, the company needs to adapt its previous visions in order to satisfy the diversifying needs of the times and customers. Under the new environmental vision of an “environmentally creative organisation”, the housing company adopted the PSS strategy.



Figure 2: Example of a prefabricated unit house [15]

Why do customers rebuild a new house? A survey discovered that most of the unit house customers rebuild their houses not because of the age or the condition of the house, but because they desire new living arrangements (different size, layout, style, etc.) [4]. These consumer demands were projected to grow and become even more diversified when considering the growing number of aging population and the changes in family structure.

4.2 System Design

Before implementing the PSS strategy, old unit houses were disassembled and landfilled, or at best partially handed over to material recyclers. From an environmental point of view, disposing of and even destroying modular components with intact quality was a major loss. Some structural elements, such as steel beams, can last for approximately 150 years without quality degradation. According to a research, however, the average lifespan of a house in Japan is only 26 years [8]. This incongruence between the material lifetime and the actual use time indicated the necessity and the opportunity for service solutions.

To fulfil the consumers’ demand with less environmental burden, and to realize the goal of the company, i.e. long-term use of unit houses and materials, the technical and economic performance of the unit housing system was systematically analysed with the support of tools such as variables checklist, cross impact analysis, System Map, and system SWOT (for detailed descriptions of these tools, see [7]). Key stakeholders were identified and invited for workshops where they collaboratively built up a number of system scenarios.

As a result, the following resource-recycling housing system was developed and launched [5,7,23]. The company buys back old houses, disassembles them into units on site, and transports the units to one of its production facilities for re-manufacturing. Figure illustrates the material flow.

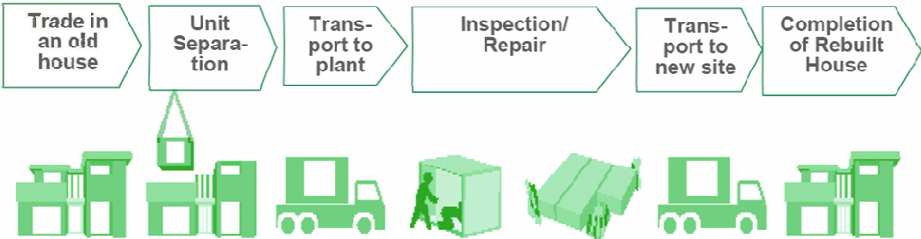


Figure 3: Material flow of prefabricated unit house reuse system [5]

4.3 Environmental Performance

Through the take-back and re-manufacturing services, major parts of old modular houses can be reused. Systematic improvement of the refurbishment processes increased component reuse ratio, and consequently the volume of waste was reduced. According to quantitative evaluation entitled “Life-cycle Impact Assessment Method based on Endpoint Modelling”, this method enables more than 85% of the weight of the original house to be reused (Figure 4). Compared with the construction of a new building, the reuse system turned out to reduce environmental impact (calculated based on ‘damage cost’²) by 1.03 million Yen per unit. To increase future unit reuse, the company currently puts greater emphasis on the design of parts and material selection.

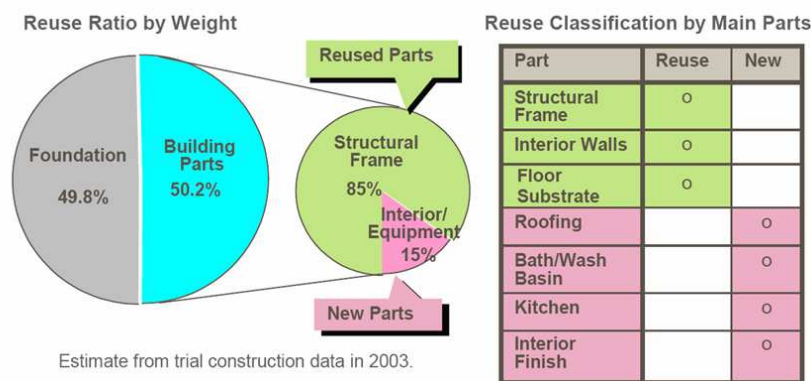


Figure 4: Reuse ratio and reuse classification [5]

4.4 Requirements for Market Success

Technically speaking, the unit reuse system turned out to be superior to rebuilding a new unit house in many terms: It has the same basic function (i.e. a living space), its quality is equivalent with that of a new house, it generates less waste, and it is more economical. Nevertheless, the business strategy was not perceived to be remarkably successful at the beginning of its market launching. What hinders its market success? Could there be other critical values determining market acceptance in the B2C market?

Earlier, the authors established a hypothesis in the fundamental research on PSS: Emotional and socio-symbolic values engaged with a PSS solution are critical factors for the market success of the solution [22]. In the context of PSS, emotions mean the sensory values experienced in product and service use. These values can be overall product and service properties or some particular details or features of the system. This hypothesis was derived from examining the highly successful product sales strategy and monitoring its marketing and branding trends in the past [22]. Scholl underpins this hypothesis by arguing that symbolic values of a product can be regarded more decisive than functional properties of products [14]. People buy *products* to bolster their self-image. As many social scientists and psychologists revealed, the emotional value is one of the essential elements in modern consumption culture [2,11,13]. It is supposed that people may buy *services* for the same reason. Under this hypothesis, the basic unit reuse system was analysed with focus on the emotional and socio-symbolic values engaged in the solution and its marketing strategies. The well-known SWOT analysis method and a specifically adopted system SWOT analysis (see [7,22]) were utilised as tools for the study. Stakeholders’ comments,

² Damage cost is the cost incurred by repercussions (effects) of direct environmental impacts (for example, from the emission of pollutants) such as the degradation of land or human-made structures and health effects. In environmental accounting, it is part of the costs borne by economic agents [10].

consumer survey results, and interviews with management board members were also considered as valuable data for improving emotional aspects of the PSS strategy.

The following key problems and findings were derived:

- In general, 'second-hand' products are perceived to have lower qualities than new ones. Therefore, the reused unit houses create unfavourable images though they were mostly refurbished.
- Potential clients have to make a decision for purchase or lease of a unit house before the units are actually refurbished. Therefore, the clients take a risk when making a contract, without seeing their future property.
- The environmental benefit of the solution (e.g. waste reduction) is appreciated by clients. Yet, this does not seriously influence their decision making.
- Owners of the original houses are satisfied that their houses are rebuilt into new houses instead of being demolished and discarded.

5. Results

5.1 Solution Improvement

A prime consideration was to convert the negative image attached to 'second-hand' products into a positive one. A number of promotion and marketing ideas were generated through stakeholder workshops and brainstorming sessions. For instance, a 'test-living in resort areas' can give customers an opportunity to experience the high quality of refurbished houses, which often exceeds their expectations. This allows customers to try out the actual product before they make a leasing decision. Another example is a corporate social responsibility (CSR) activity providing temporary shelters with refurbished units for refugees in disaster areas, such as after earthquakes.

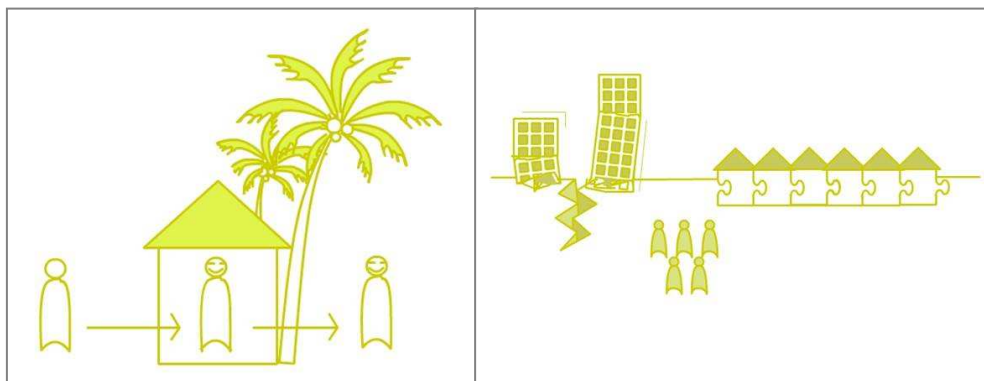


Figure 5: Test living unit at resorts (left) and temporary shelters (right)

5.2 Design Guideline for Emotional PSS

Based on the design practice and references to other authors' suggestions, a simple guideline was elaborated to help system developers take the non-technical properties into account in the design of a PSS solution. Different PSS models require different sets of emotional and symbolic values. For instance, convenience and safety are more important than exclusivity when it comes to PSS solutions for public transport services (e.g. a city-bike rental service), while exclusivity is more required in individual services (e.g. designer's handbag rental service). The following list of emotional and socio-symbolic values can be classified in a different way, and other values can be added.

Table 1: Guidelines for emotional PSS design and marketing (based on [14,17,23,24])

Value Classifications	Design Guidelines
Comfort and usability (mastery of the object, high quality of interaction between the employee and the customer)	The goods delivered for the service should be self-explanatory and easy to operate. A clear design of the product and plain instructions should be provided either by the personnel or by simple manuals. Utilise the flexible value proposition of services as an advantage. Service providers can educate personnel for the PSS offer to quickly specify customer's needs and to provide customised values (e.g. competence and friendly appearance of contact personnel).
Convenience (maximising ease of access to the service offer)	Easy access to the service offer can restore options of control for the customer over the products provided (e.g., flexible opening hours, online booking, and delivery services are practical means). Information technologies are useful to deliver convenient services to users.
Reduction of risk	Negative images should be eliminated. Doubts and concerns of customers should be gathered to be solved in the design process. The appropriate solutions can be used even as advertisement themes, so as to turn the negative emotions into positive ones. For example, users have concerns about the hygienic state of shared or rent products (e.g. pram, toys). Providing a cleaning system between different uses and presenting the results can be a solution and a strong marketing tool at the same time.
Amusement value and image (high quality of physical surrounding of the service, extending the scope of the service offer)	The pleasure of the service experience (e.g. clear signage and good ventilation, in combination with proper spatial layout and good functionality). Not only in product design, but also in services, fun factors can be included. The success of launderette service combined with a drinking lounge, space for art performances, or an internet café is an example. Increase the amount and variety of available rental goods to ensure that demands can be met properly, and offer superior quality goods (e.g. car sharing services with a fleet covering small cars and limousines as well as cabriolets and vans).
Exclusivity	Offering exclusive access through membership service is one possible approach. The key to the success of membership service exists in the fact that members experience the particularities. Using high quality products is a prerequisite to provide secured results.
Addiction	In this context, the term refers to the factors which can encourage the customer to repeat the use of the service, without returning to the conventional product-purchase solutions.
Dissemination	This aspect means that users can share the PSS experience with others. Normally, people want to represent themselves through what they have. This social meaning of products can be implanted in use of services. Word-of-mouth is a good PR method. For instance, other customers' reviews in hotel reservation services affect other customers' decision-making.

6. Conclusions

Orientating consumer behaviour is a considerable challenge in implementing PSS because consumers are accustomed to product sales offers. With the help of systematic methodologies and continuous design practices through industrial applications, more PSS solutions can be developed and implemented.

The refurbishing and reuse system enlarged the prefabricated-housing business from mere sales of houses to a service that provides flexible living spaces for private and commercial clients. In the design of the PSS solution, emotional and socio-symbolic values were perceived to be highly important for market acceptance. To back up this aspect, a set of design guideline was suggested. Other case studies conducted by authors and further analyses also underpinned the claim that PSS should provide positive emotional and socio-symbolic values in order to compete with the product sales offers in the market. In the scarcity of industrial application of PSS development methodologies, this case study serves as a useful reference for sustainable and competitive PSS design.

7. References and Citations

- [1] Brezet, J.C., Bijma, A.S., Ehrenfeld, J. and Silvester, S. (2001) The Design of Eco-Efficient Services: Method, Tools and Review of the Case Study based 'Designing Eco-efficient Services' Project. Design for Sustainability Program, Delft University of Technology. Delft, the Netherlands, pp. 6-8.
- [2] Dittmar, H. (2004) Understanding and Diagnosing Compulsive Buying. In *Addictive Disorders: A Practical Handbook*. R. Coombs (Ed.), Chapter 13. New York: Wiley.
- [3] Goedkoop, M., van Halen, C., te Riele, H and Rommens, P. (1999) Product Service Systems, Ecological and Economic Basics. Vrom, EZ. Hague, the Netherlands, p.18, Annex document.
- [4] Iwahara, T. and Suzuki, Y. (2005) Reuse System of Industrialised Houses (Reused System House). In *Proceedings of the Fifth World Sustainable Building Conference*, pp. 1211-1218.
- [5] Jakl, T., Joas, R., Nolte, R. and Schott, R. and Windsperger, A. (2004) *Chemical Leasing: an Intelligent and Integrated Business Model with a View to Sustainable Development in Materials Management*. Springer-Verlag, Vienna, Austria.
- [6] Jensen, R. (1999) *The Dream Society: How the Coming Shift from Information to Imagination will Transform Your Business*. McGraw-Hill.
- [7] Kang, M.J. (2009) *Development of Sustainable and Competitive Product Service System Solutions: Verification and Improvement of Methods and Tools*. Vienna, Austria.
- [8] Magnier, M. (2002) Home-Buyers in Japan up against a Stacked Deck. In *Los Angeles Times*. March 6, 2002.
- [9] Mont, O. (2001) *Introducing and Developing a Product-Service System (PSS) Concept in Sweden*. The International Institute for Industrial Environmental Economics.
- [10] OECD. *Glossary of Statistical Terms*. Available at <<http://stats.oecd.org/glossary/detail.asp?ID=530>> [Accessed 22 April 2009].
- [11] O'Shaughnessy, J. and O'Shaughnessy, N.J. (2003) *The Marketing Power of Emotion*. Oxford University Press.
- [12] Quist, J., Knot, M., van der Wel, M. and Vergragt, Ph. (1999) Strategies for Sustainable Households. In *2nd International Symposium on Sustainable Household Consumption 'Household Metabolism: from concept to application'*. pp. 175-186.
- [13] Ries, A., Trout, J. and Temporal, P. (2004) *The 22 Immutable Laws of Marketing in Asia*. John Wiley & Sons (Asia) Pte Ltd.
- [14] Scholl, G. (2006) Product Service Systems. In *Proceedings for Workshop of SCORE! Network*.
- [15] Sekisui Heim Guide (2006). Available at <http://www.uru.sekisuiheim.com/saichiku/index/s_saichiku.html> [Accessed 3 December 2008]
- [16] Stoughton, M., Horie, Y., Nakao, Y. and Gunjima, T. (2007) *Service-led Businesses for Sustainability? Evaluating the Potential of and Policy for Innovative Product Service Systems in Japan*. Institute for Global Environmental Strategies – Kansai Research Centre. Japan. pp. ES16-17.

- [17] Tukker, A. and van Halen, C. (2003) *Innovation Scan for Product-Service Systems: A Manual for the Development of New Product Service Systems for Companies and Intermediaries for the SME Sector*. Delft/Utrecht, the Netherlands.
- [18] van der Horst, T., Vergragt, P. and Silvester, S. (1999) Sustainable Roadmapping: New Approaches for Identifying Radical Product System Innovations. In *Greening of Industry Network Conference Best Paper Proceedings*.
- [19] van Halen, C., Vezzoli, C. and Wimmer, R. (2005) *Methodology for Product Service Innovation (MEPSS): How to Implement Clean, Clever and Competitive Strategies in Companies*. Koninklijke van Gorcum, Assen, the Netherlands. p. 35.
- [20] Wimmer, R. (2003) Success and Failure Factors of Product-Service Systems. In *Proceeding of Sustainable Innovation 03 - Creating Sustainable Products, Services and Product-Service-Systems*.
- [21] Wimmer, R. and Grimaldi, F. (2005) Stakeholders' Involvement - a Tool for Organizational Strategies that Allows to Combine a Market Driven Approach Increasing Competitiveness and Reducing Environmental Impacts. In *SETAC Conference 2005*.
- [22] Wimmer, R., Kang, M.J., and Lee, K.P. (2006) Emotional PSS Design: Beyond the Function. In *Proceedings of Launch conference of the SCORE! Network*.
- [23] Wimmer, R., Kang, M.J., Tischner, U., Verkuijl, M., Fresner, J. & Möller, M. (2007) *Success Strategies for Product Service Systems, Final Report*. Federal Ministry for Transport, Innovation and Technology (BMVIT): Factory of Tomorrow (Fabrik der Zukunft) Program.
- [24] Xue, L. and Yen, C.C. (2007) Towards Female Preferences in Design – A Pilot Study. In *International Journal of Design*, 1(3), pp. 11-27.