

# Generation of Concepts for Product-Service System

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## Abstract

Product-service system (PSS) provides a strategic alternative to product-oriented economic growth and severe price competition in the global market. The objective of this research is to develop a systematic methodology to generate concepts for new PSSs, called a PSS concept generation support system. The models and strategies of more than ninety existing PSS cases are analyzed, and the insights extracted from the analysis are used to facilitate the concept generation process. The generated PSS concepts, after some screening and elaboration, can evolve to new business models for PSS.

## Keywords

Product-service system, PSS Concept, PSS Development, PSS Model

## 1 INTRODUCTION

Today, world governments and industries pursue green and service-oriented growth for sustainability and competitiveness. Thus, they may consider the introduction of product-service systems (PSSs) to the marketplace to accelerate the growth. A PSS is "a specific type of value proposition that a business (network) offers to (or co-produces with) its clients. A PSS 'consists of a mix of tangible products and intangible services designed and combined so that they jointly are capable of fulfilling final customer needs'" [1]. Representative examples of the PSS are car-sharing, chemical management services (CMS), launderettes, lighting system solution and document management solutions [2, 3].

A PSS designer can follow the generic process of PSS development to develop new innovative PSSs: 1) strategic planning, 2) PSS concept development, 3) detailed PSS process design, and 4) implementation. The designer analyzes the internal and external environments of the company and customer needs that he/she faces in the first step. A clear understanding of customer needs is essential in this step. Then, the designer develops PSS concepts in the second step. The concepts should be adequate and innovative enough to solve customer needs in a better way. Based on these concepts, the designer structures a detailed process in the third step. Stakeholders, products, services and interactions among any of these should be expressed in the process. Testing, marketing, and introducing the PSS business model to retailers are the last step. During the process, each step must be properly evaluated to have the balance for successful PSS development.

This research focuses on the PSS concept development step, with an emphasis on generating innovative PSS concepts. Here, PSS concept means the broad outline of a PSS business model. The concept should solve customer needs and describe what to offer, how to offer it, what its benefits are and who the stakeholders are. The generation of adequate and innovative PSS concepts is a kernel part for successful PSS development since the concept describes the general picture of the PSS which will be developed. Proven and appropriate research on

methodology supporting the PSS concept generation is required to realize the potential of PSS.

This research proposes a systematic methodology to support the PSS concept generation, called the PSS concept generation support system (PSS CGSS). This research assumes that the strategic planning is done and customer needs are identified and given for use in the PSS CGSS. Simply, its philosophy is to reduce a real problem into a general problem and then provide a general solution to the general problem. A real solution is then generated based on the general solutions. It was developed based on the analysis of 94 PSS cases. It consists of a set of 4 tools and the PSS concept generation procedure. The tools are the general needs table, the PSS models table, the PSS case book and the concept generation support matrix (PSS CGSM), and the procedure consists of 3 phases: 1) identify general needs, 2) consult existing PSS knowledge-base, and 3) generate PSS concepts.

The proposed PSS CGSS helps the designer generate a number of PSS concepts easily, by following the procedure and using the tools systematically. It explicitly and implicitly provides the expertise to generate innovative PSS concepts, by using the rich experiences of various existing PSS cases.

Section 2 provides the review of literature related with this research. Section 3 proposes PSS CGSS. Section 4 illustrates the proposed PSS CGSS through a case study on the laundry industry. Finally, Section 5 gives our concluding remarks.

## 2 REVIEW OF RELATED LITERATURE

Notwithstanding the rapid growth of the PSS literature [see, e.g. 1, 2, 3, 4, 5], development of a systematic methodology supporting PSS development has not been well addressed. Research related with PSS concept generation is briefly reviewed in this section. Research on concept development in the context of new product development (NPD) and new service development (NSD) is reviewed, and then existing PSS concept development is reviewed.

## 2.1 Review of the concept development in NPD and NSD

The product concept means “an approximate description of the technology, working principles and form of the product” [6]. Ulrich and Eppinger’s NPD process generates product concepts through the 5 step method, which is 1) clarify the problem, 2) search externally, 3) search internally, 4) explore systematically, and 5) reflect on the solutions and the process, based on customer needs and target specifications [6].

Hideki [7] proposed a Quality Function Deployment (QFD) integrated systematic methodology for eco-product concept development, named the product life cycle planning (LCP) methodology. The LCP methodology consists of 5 steps and various supporting software tools. Ulrich [8] proposed an ideal eco-product concept development approach focusing directly on customer needs. It consists of 6 steps to develop a product concept unifying extreme ways to reduce specific environmental impacts. The RemPro-matrix [9] is a tool showing the relationship between essential product properties and the generic remanufacturing process steps. The matrix can be used to identify product concept properties facilitating the development of a remanufactured eco-product. Yang and Chen [10] proposed a method supporting eco-innovative product design using TRIZ [11] and case-based reasoning. The method helps develop an eco-product concept by retrieving the prior experiences of eco-innovative product cases. The method would become more powerful as more cases are accumulated in the case base.

The service concept defines what to offer to customers and how to offer it, and mediates between customer needs and the strategic intent [12]. The service concept development is considered an important step in various NSD process models. In Scheuing and Johnson NSD process [13], a service concept is developed based on the idea screened in the previous step. Fisher and Schutta [14] employee QFD to translate customer needs into the technical requirements of a service concept. Sakao and Shimomura [15] proposed a computer tool to develop functions based on identified customer needs, yielding a result analogous to a service concept. Chai et al. [16] proposed a problem solving model for new service concept development based on TRIZ. Kim et al. [17] proposed a systematic framework for developing new service concepts, with an emphasis on generating innovative convergence-type service concepts from the customer’s perspective.

Though the aforementioned works are helpful to develop the product or service part of a PSS concept, it is highly limiting to use only the product or service perspective in developing a PSS concept. The PSS concept development methodology should consider both the product and service perspectives [18] of PSS.

## 2.2 Review of the concept development in PSS

Though the designer can consult NPD and NSD, the PSS development process should be different from NPD and NSD since a PSS is not just a product or service. The designer should consider issues such as the involvement of various stakeholders, the relationship of product and service and indistinct ownership. There is much less research on PSS development compared to NPD and NSD. Methodologies for product-service systems (MEPSS; [19]) and (Chen and Huang, [20]) are representative.

MEPSS proposed a 5 phase PSS development process, which is 1) strategic analysis, 2) exploring opportunities, 3) PSS idea development, 4) PSS development, and 5) implementation preparation. The designers build a PSS

scenario in the second step and PSS idea in the third step. Conceptually, our term PSS concept has an intermediate meaning between the terms PSS idea and PSS scenario in MEPSS, in terms of the degree of description level (scope). A PSS idea defines the precise and detailed definition of what the PSS is going to offer, how the core function could be delivered” and “stakeholders of the PSS and the interactions among them”. It is represented through various tools such as the offering diagram, the stakeholder system map and the interaction table. A PSS scenario is a draft version of a PSS idea in MEPSS.

MEPSS provides more tools, such as the stakeholder involvement planning tool, the system analysis tool and the inventory of sustainability indicator, than the tools mentioned above to develop the scenario and the idea. They help designers generate appropriate concepts based on the PSS philosophy. MEPSS is useful in terms of its comprehensive coverage of the whole PSS development process through a step-by-step procedure with the supporting tools. However, it does not provide a sufficient knowledge-base for scenario and idea development. It explains how to use the tools to get the content of a PSS model, but the designer still must create the content independently. A tool that supports this task would make the process faster and easier.

Chen and Huang proposed the TRIZ based eco-innovation methodology to generate PSS ideas. The term PSS idea in their paper is analogous to the term PSS concept in this paper. The methodology provides 1) the rules for planning new PSS and related TRIZ inventive principles with the rules and 2) the PSS items and evolution trends and ideal final results of the items for PSS innovation. These help the designer generate PSS ideas more easily. However, the methodology does not help designers choose the rules and the items appropriate to their specific PSS problems. Their research just leaves the task to the designer. Also just altering TRIZ to PSS is not appropriate in many cases because of inherent differences between a physical product and a PSS. Designers need a systematic approach to when and how to use the outputs of this research.

The proposed methodology PSS CGSS aims to provide a systematic procedure and supporting tools for the generation of innovative new PSS concepts. It provides the knowledge-base telling how and where to get the knowledge for concept generation. Moreover, it provides guidelines to determine which solutions are appropriate to solve the customer needs that are the problems of the company. 6 points after the equation, as indicated in the Equation style on the Word template.

## 3 PSS CONCEPT GENERATION SUPPORT SYSTEM

Figure 1 shows the overview of the proposed PSS CGSS approach. First, given customer needs are transformed to general customer needs (general needs) using the general needs table. Second, PSS models and PSS cases to solve the general needs are identified using the PSS CGSM, the PSS models table and the PSS case book. Third, PSS concept that solves customer needs is generated based on the knowledge from PSS models and the PSS cases and represented in the representation scheme. The upper half and the lower half of Figure 1 represent the problem of the designer and the solution of the problem, respectively. Customer needs are generalized as they are transformed to the general problem and PSS concept is generated based on the general solutions. The aforementioned tools and PSS concept generation procedure are explained below.

### 3.1 General needs table

Customer needs vary widely since they are highly dependent on the specific PSS case. A specific solution (concept) for a specific customer need is not easy to find in the real world.

If the customer needs are reduced to their core (general) meaning, the solution is much easier to find. In this sense, the PSS CGSS suggests 22 general needs. The 22 general needs are ordered according to the PSS life cycle from the customer's perspective: purchase (#1 to #3) – use/maintenance (#4 to #19) – disposal (#20 to #22). They are described in the general needs table. Table 1 shows three examples. The designer can transform specific customer needs into general needs using the table. Thus, the customer needs “Customer wants to use the product engine in the best condition.” and “Customer wants to know the most suitable way to use cosmetics.” can be transformed into general need #7 (need of optimized use).

### 3.2 PSS models table

A PSS model is a reference model that helps the designer solve customer needs. Existing PSS cases such as CMS, car sharing, or document management systems can be classified in line with PSS schemes that company used. The CMS, for example, helps customers more conveniently keep chemicals safe and dispose of them. The need is solved through services to control chemicals safely and to dispose of them for the customers. The first service is a control service scheme. The second one is an agent service scheme. Other companies can adopt those control service and agent service schemes to solve similar customer needs. In this research, those schemes are classified as PSS models. A control service scheme is

classified as PSS model #5 (maintenance service) and an agent service is classified as PSS model #10 (broker & agency service). The proposed PSS CGSS provides 26 PSS models to support the PSS concept generation.

The 26 PSS models are described in the PSS models table. The models are ordered according to the degree of relationship with PSS category [5]: product-oriented PSS (#1 to #16) - use-oriented PSS (#17 to #21) - result-oriented PSS (#22 to #24) - others (#25 and #26). Table 2 shows three examples.

### 3.3 PSS CGSM

The 22 general needs and the 26 PSS models are thought to be highly related. For example, CMS solves general need #7 (need of optimized use) by PSS model #10 (broker & agency service). The PSS CGSM is the matrix showing all the need solving relationships (processes). Figure 2 shows a small portion of the PSS CGSM. The first column of the matrix shows the 22 general needs and the first row shows the 26 PSS models. Intersections of the column and the row show the numbers of the PSS cases. Thus, the designer can identify which the PSS models were used to solve a certain general need and which cases are related.

The 94 PSS cases are stored in the PSS case book in the Microsoft Office Excel format. They are described through several categories: 1) no., 2) company name and PSS title, 3) target customers, 4) customer needs solved, 5) PSS models used, 6) what to offer, 7) how to offer it, 8) stakeholders, 9) benefits, and 10) reference. The contents of the PSS case book are not shown in this paper due to the lack of space, but can be provided upon request.

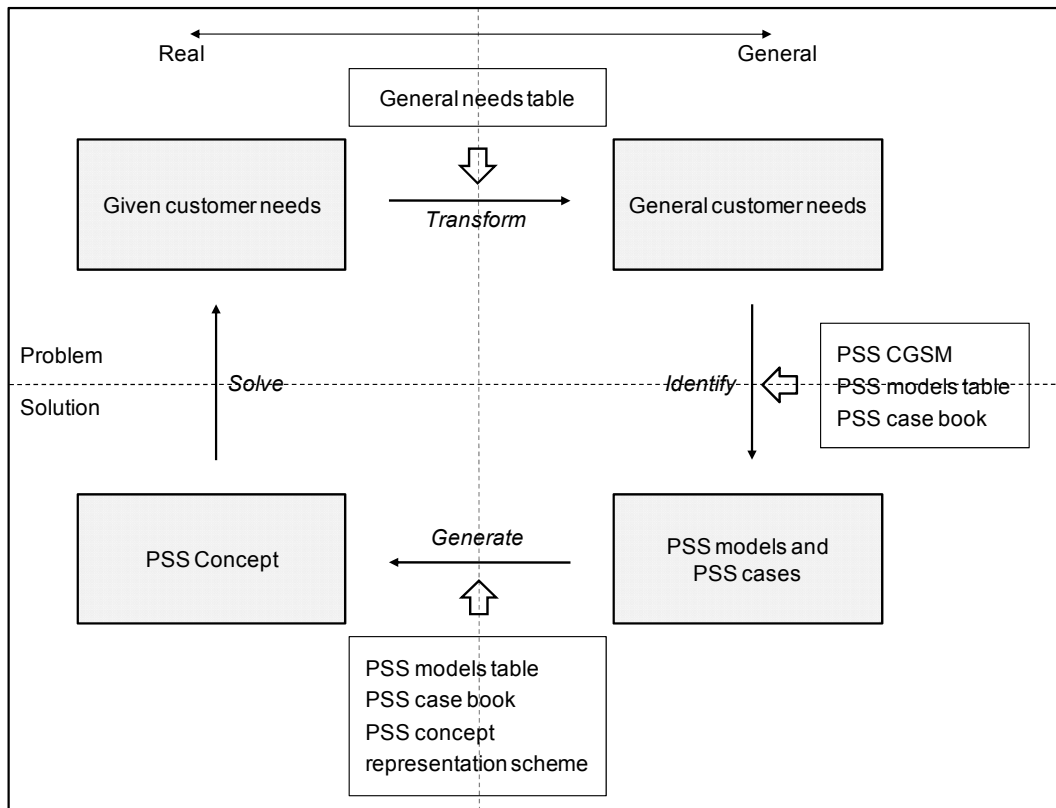


Figure 1: The approach of the proposed PSS CGSS.

General needs	Description
4. Information providing service	Give customer needed information over products/services life cycle.
7. Optimized use	Customer wants to use optimized products/services in the best condition/environment.
17. Expansion of an access route of use	Create and offer new way to access products/services.

Table 1: General needs - three examples.

PSS Models	Description
5. Maintenance service	Control, repair, monitor products/services.
10. Broker & agency service	Conduct work instead of customers.
22. Guarantee contract & authorization	Guarantee an excellent result of products/services use. Customer authorizes almost everything about products/services use.

Table 2: PSS models - three examples.

PSS models		Product-oriented PSS							
		M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8
Purchase	N 1		81, 82		90				
	N 2								
	N 3			2, 4	3, 51, 83, 90		3, 43, 50, 83, 93	11, 44, 49, 57, 93	...
Use	N 4								
	N 5	77							
	N 6					37, 76, 77, 86	*	37	

(\*): 9 16 17 76 77 83 88

Figure 2: Format of CGSM.

Phase	Step	Supporting Tools	Outputs
1. Identify general needs	1.1. Refine customer needs	- General needs table	- The general needs of the customer needs
	1.2. Transform customer needs into general needs		
2. Consult existing PSS knowledge-base	2.1. Identify PSS models	- PSS CGSM - PSS models table - PSS case book	- PSS models selected to solve the general needs - PSS cases of the need solving processes
	2.2. Identify PSS cases		
3. Generate PSS concepts	3.1. Generate ideas for PSS concepts	- PSS models table - PSS case book - PSS concept representation scheme	- PSS ideas to solve the customer needs - PSS concepts - Final PSS concept representation
	3.2. Form PSS concepts		
	3.3. Represent PSS concepts		

Figure 3: The PSS concepts generation procedure.

### 3.4 PSS concepts generation procedure

Figure 3 shows the PSS concept generation procedure, supporting tools and outputs of each phase. The procedure consists of 3 main phases and 6 sub steps. PSS CGSS assumes that customer needs are given as the input information. General needs are identified in phase 1. The existing PSS knowledge-base is consulted in phase 2. Finally, PSS concepts are generated in phase 3. Detailed explanations of each sub step follow.

Various specific customer opinions are refined to customer needs in Step 1.1. The requirements of refinement are 1) customer need should be expressed in terms of what the product has to do, not in terms of how it might do, 2) customer need should be expressed in positive, not negative phrasing, and 3) customer need should avoid the words “must” and “should” [6]. Once the specific customer needs are refined, they are transformed into general needs, using the general needs table in the Step 1.2. A customer need can be transformed to several general needs, and several customer needs can be transformed to a general need.

PSS models to solve the general needs are identified using PSS CGSM and PSS models table in Step 2.1. PSS cases in which the need solving process occurred are identified, using PSS CGSM and the PSS case book in the Step 2.2.

Based on the knowledge from phase 2, various innovative ideas to solve the needs are generated by brainstorming in Step 3.1. PSS concepts are formed based on these ideas in Step 3.2. An idea can be expanded to a concept or similar ideas can be integrated to a concept through affinity diagramming. Every generated PSS concept is represented in the representation scheme in Step 3.3. The scheme defines the scope and the needed information of a PSS concept. It consists of 1) the number of the concept, 2) its name, 3) a short description, 4) problems

that it solves, 5) target customers, 6) what to offer, 7) how to offer it, 8) stakeholders, and 9) benefits.

### 4 CASE STUDY ON A LAUNDRY INDUSTRY

A case study was conducted on an imaginary company to validate and verify the usefulness and reliability of the proposed PSS CGSS. The company manufactures washing machines and provides related services. Eleven hypothetical customer needs were generated. Then, they were refined and transformed to 12 general needs using the general needs table in the first phase. Various PSS models and cases to solve the needs were identified and consulted using the PSS CGSM, the PSS models table and the PSS case book in the second phase. Four different PSS concepts were formed based on the ideas generated using the knowledge consulted in the third phase. They are 1) Cleaner life 2) A fabric cleaner 3) A good laundry man 4) V.I.P washer. Finally, they were represented in the representation scheme.

Figure 4 shows how the “Cleaner life” PSS concept was generated. First, customer needs i, ii and viii were refined and transformed into general needs #4, #15 and #7 & #17 respectively. Second, various PSS models (e.g. total package solution and sharing) and cases (#13, #57, etc.) were identified and consulted. The PSS models and cases highlighted by dotted lines in Figure 4 were especially fruitful for the concept generation (see the case #13: Intelligent bedroom PSS of Panasonic [21], #57: Greenstar village e-commerce centre PSS [22] and #67: Painting solution PSS of PPG [23]). Third, several ideas were generated to solve the general needs. Fourth, the concept was formed based on the ideas. The generated “Cleaner life” PSS concept provides a washing machine with wastewater sanitation function or device through various services to protect water supplies. Finally, it was represented in the representation scheme (see Table 3).

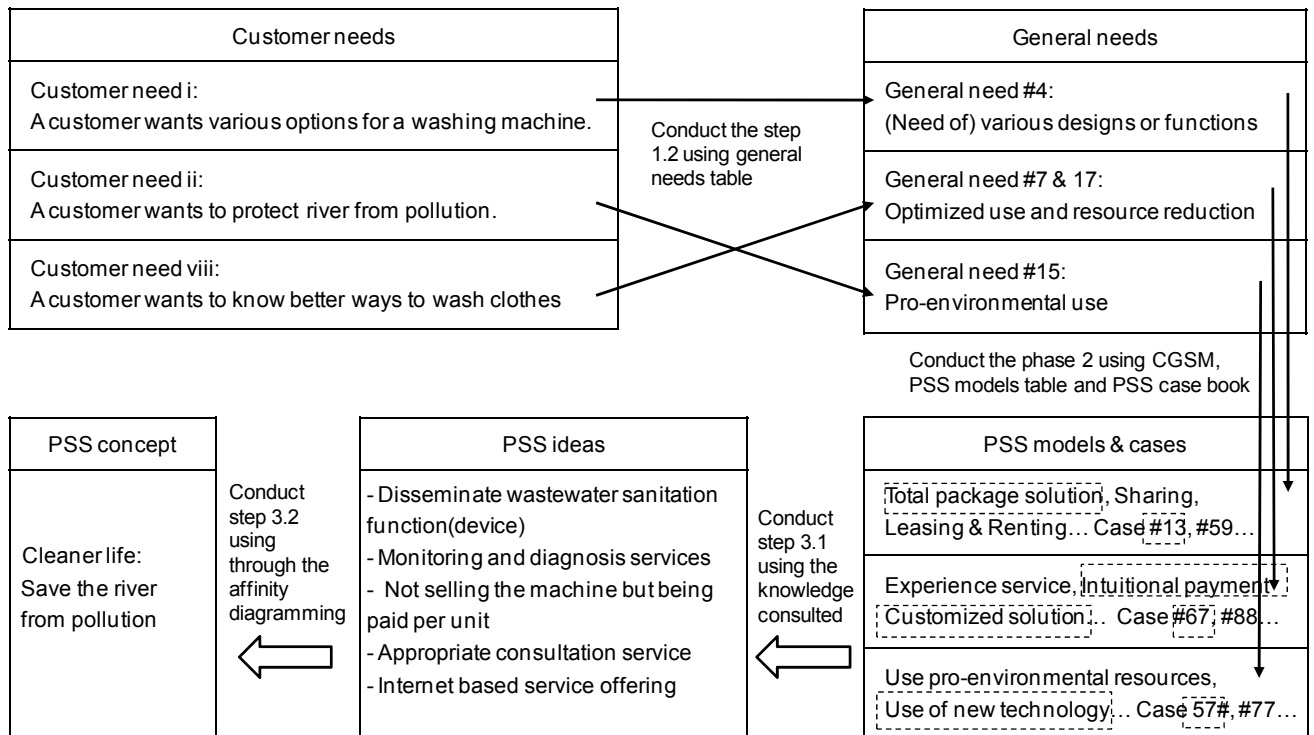


Figure 4: Generation of the “Cleaner life” PSS concept is generated.

<p>No. 1: Cleaner life: Save the river from the pollution</p> <ul style="list-style-type: none"> <li>- Provide a washing machine with wastewater sanitation function or device through various services.</li> </ul>	
<p>Problems</p> <ul style="list-style-type: none"> <li>- Not various washing machines designs or functions</li> <li>- Concern about polluted river</li> </ul>	<p>Target customers</p> <ul style="list-style-type: none"> <li>- Customers who are sensitive with environmental issues</li> <li>- Customers who are looking for better way to wash clothes</li> <li>- Customers who are interested in new technology, such as early adopters</li> </ul>
<p>What to offer</p> <ul style="list-style-type: none"> <li>- Washing machine with function or device to make wastewater clean</li> <li>- Monitoring and diagnosis services to analyze pollution</li> <li>- Customized maintenance and consultation services to discharge the least pollution</li> </ul>	<p>How to offer it</p> <ul style="list-style-type: none"> <li>- Product and services are offered in the packaged form</li> <li>- No additional charge to the function or device when washing machine is upgraded</li> <li>- Maintaining, monitoring, diagnosing and consulting through wireless communication</li> <li>- PSS is paid per liter of water used based on the membership contract</li> </ul>
<p>Stakeholders</p> <ul style="list-style-type: none"> <li>- Washing machine manufacturer</li> <li>- Technology owner</li> <li>- Customers</li> <li>- Government or organizations concern environmental issues</li> </ul>	<p>Benefits</p> <ul style="list-style-type: none"> <li>- Economic values added: high customer loyalty, guaranteed profit, possible tax exemption, high entry barrier</li> <li>- Environmental &amp; social values added: pollution decrease, pro-environmental atmosphere of society</li> </ul>

Table 3: Cleaner life.

The “A fabric cleaner” PSS concept provides a fabric cleaning service, not a washing machine product only. The provider guarantees clean fabrics based on a pay per week contract. The “A good laundry man” PSS supplies used washing machines to appropriate places such as undeveloped countries or other poor areas. The provider contracts with various governments and attracts customers by sharing profits created or upgrading products. The “V.I.P. washer” provides a membership service to use washing machines and consults with customers on how to use washing machine better. Leasing service is offered based on pay per month contract, and the consulting service is provided through internet.

Economic values-added such as high revenue creation and market share increase can be achieved through environmental incentives by offering well integrated product-services [24, 25]. Environmental and social values-added also can be achieved through economic values-added. It is notable that the PSS concepts generated in the case study create economic, environmental and social values-added through both economic and environmental incentives. For example, the “Cleaner life” PSS concept attracts pro-environmental customers by introducing the wastewater sanitation function, an environmental incentive. The washing machine manufacturers can create economic values-added through the concept. The “A good laundry man” PSS concept attracts customers by the profit share which is the economic incentive. The companies and governments can create environmental and social values-added through the concept.

After the case study, it was felt that the knowledge-base of the CGSS can help PSS designers generate innovative PSS concepts in a systematic manner. The concepts that were generated may have been quite difficult to devise just in a conventional brainstorming without a systematic

support. Moreover, the concept generation process of the case study was simple and easy to follow. In summary, the proposed PSS CGSS can be an efficient and effective aid to PSS designers for PSS development..

## 5 CONCLUDING REMARKS

This paper proposes a methodology to support PSS concept generation, called the PSS CGSS. It is developed based on the analysis of 94 PSS cases. It consists of a set of 4 tools and the PSS concept generation procedure. The designer can identify PSS models and PSS cases to solve customer needs using the PSS CGSM. He/she can generate the PSS concepts to solve the needs based on the knowledge in the models and the cases. The procedure systematically supports the generation process. A case study was also conducted to verify and validate the proposed PSS CGSS, and the result was satisfactory.

Generating adequate innovative PSS concepts is a kernel part of successful PSS development as mentioned in the Section 1. This research is the first to support the PSS concept development systematically. The tools reflect rich prior experience of various existing PSS cases. The knowledge-base infrastructure provided by the tools materializes the potential of PSS (potential to create economic, environmental and social values-added) through both economic and environmental incentives. Thus, these tools can be used to generate innovative PSS concepts addressing a variety of customer needs in many different contexts.

Also, the systematic procedure is clear and easy to follow. The designer can generate PSS concepts easily and naturally while following the procedure. He/she only needs customer needs data as the seeds of the generation. In conclusion, PSS CGSS use increases the success likelihood of PSS development and decreases the amount

of trial and error. This research should accelerate research on adequate PSS development methodology.

There are several issues for the further research to improve the PSS CGSS to a widely used generic platform for the many companies' PSS development. First, more PSS cases should be collected and analyzed since the core value of the PSS CGSS depends on good empirical study. It will become more effective, efficient and reliable as more innovative cases are analyzed and offered. Second, both the comprehensiveness and exclusiveness of the lists of general needs and PSS models should be improved through systematic and continuing validation/verification. Third, the link among general needs, PSS models and PSS cases also should be improved through the validation/verification. Case studies on real companies are required.

## 6 ACKNOWLEDGEMENT

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