Chapter 16
Design Management Intervention in Product–Service System of Water Supply

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Abstract Strategic design management in product–service system in the context of water supply is the prime focus of the study. The study formulates strategic relationships of product and service components by considering life cycle perspective of water supply system. The process diagram of the water supply system of the community was developed on the basis of initial system study. Personal interview was conducted with the people in maintenance section of the water supply system to gather information about overall water supply system from the source to the end user. It has been observed that the water supply system involves several small and medium firms that provide materials and manpower to the system. Quality function deployment (QFD) method is used to identify and meet customer's requirements. Strategic design thinking in integrating of products and service design could improve the uninterrupted supply of clean water. The framework developed for product–service system study and the methodology adopted in the study may provide new insights into the field of design education and research.

16.1 Introduction

Product–service system as a business model for sustainability has been discussed over the past two decades [1]. Integrating products and service is a growing trend among companies in today's globally competitive business environment [2]. A product–service system design approach is required for essential community-level services like water supply system [3]. The capability of storing,

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managing, and analyzing the large data set of water supply requires mapping and use of multi-support information system. The renovation of water treatment technologies and distribution networks could improve the water supply situation, but this requires financial resources and changes in water management operations and maintenance [4]. Service management researchers are interested in studying clean technologies, as an innovative idea for water sector [5]. The integration of the service provider, stakeholder, contractor, and the community, which is common in product service system offerings since they comprise a network of actors to contribute better management of the system. There is a lack of research on business models in water sector.

The objective of this study is to understand how PSS offerings are collective, such as life cycle maintenance of water supply system in a community. The study involved detailing of product and service components involved in water supply system and mapping of product–service components of water treatment plant, cooler, and purifier. Quality function deployment method was applied to prioritize products/service purifier components. The research presented here can contribute to the field of application of design methods, viz. product–service life cycle and quality function deployment in designing product–service system.

16.2 Methodology

Research hypothesis has been formulated that 'product–service system design thinking for strategic mapping of various product–service components of water supply system in a community can evolve better design management strategy for uninterrupted supply of clean water.' In order to find the attributes of products and services, a case-based research is considered on the basis of life cycle perspective of water supply [6]. Information was obtained through semi-structured interview (lasting 25–35 min). The respondents were supervisor of VA Tech Wabag Ltd. at water treatment plant, two assistant engineers from maintenance section and a junior assistant who looks after repair and defects of cooler and water purifier. For better understanding, observation and ethnography were also conducted at water treatment plant, water coolers, and water purifier. On the basis of the data gathered, a process diagram was developed for water supply system depicting the flow from source to end user. The entire process flow was then divided into three parts, viz. (i) source to water treatment plant, (ii) treatment plant to reservoir plant, and (iii) reservoir to end user. The detailed system study was conducted in each of the aforesaid segments of the process. Detailed process diagrams of all the segments were generated. Interactive sessions were conducted with the suppliers, engineers, and workers involved in each part of the entire system. Product and service components in all the stages of the segmented processes were identified. A matrix was developed considering product–service components of the system. The product attributes are: product, spares, and availability. The service attributes are regular maintenance, preventive maintenance, breakdown maintenance, physical facilities, people, and contract/outsourcing. Various issues of internal and external customer of the system were also taken into consideration. Structured questionnaire was administered, and personal interview was conducted to collect life cycle perspective of each product and service components of water supply.

16.3 Water Supply System—Overview

Water supply system is a system of technical elements that supply water from its source to the users that is being managed by one legal entity (usually a public service provider) and operates mainly as an independent system hydraulically separated from other systems [7]. Water supply system, in general, has various product and service components. The study was conducted in the existing water supply at Indian Institute of Technology Guwahati located in the state of Assam, India. Preliminary studies from the field visits provided an overview of water supply system. The entire system was divided into sub-categories for identification of involvement of product and service components, type of water treatment schemes, capacity, and filtration method. Edraw software was used for describing the product–service system concept [8]. The process diagrams generated were followed by mapping of product–service system components of water supply system. This exercise provided a complete and clear overview of product–service issues of system under study. It also identified the potential failure points. It further helped to determine the role and level of participation of customers and various stakeholders in the system. It explored the various factors customers and other stakeholders come in touch. It also showed areas of interactions, levels, and stresses of interaction between different actors of the system.

The flow of water and interaction of maintenance department with contractor, supplier, and consumers is shown in Fig. 16.1. Water is extracted from the Brahmaputra River through centrifugal pumps located in pump house to the water treatment plant. Filtration of raw water in water treatment plant is carried out by VA Tech Wabag Ltd. on contract basis structured by maintenance department. Filtered water is then delivered at three separate reservoir tanks, each of capacity 3 lakh liters. One is located over the hill at a distance of 500 m, and other two are located at approximately 1050 m from the treatment plant. From the reservoir tanks, filtered water is supplied to overhead tank of respective groups, viz. establishments, communities, and buildings. These groups are denoted as Group A, Group B, and Group C in Fig. 16.1. Water supply has been provided regularly to meet various functional water needs of the IIT Guwahati Community, viz. drinking, cooking, bathing, washing, flushing of toilets, gardening, centralized AC plant, institutional needs for constructions, and flushing of sewers. Supervisors at each group are appointed for smooth operation and operational maintenance such as plumbing, sanitation, and leakage. Preventative maintenance is carried out for replacement of cooler and purifier parts along with preventive inventory management.

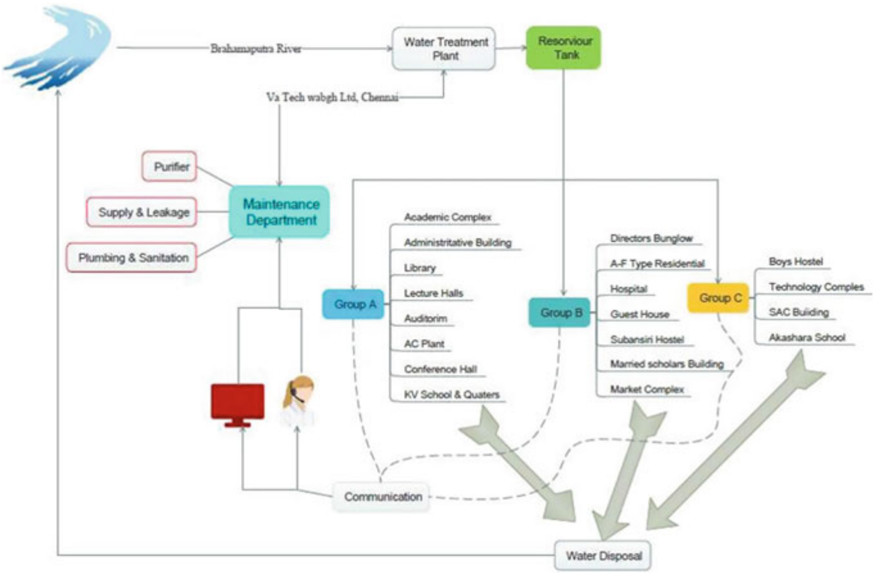


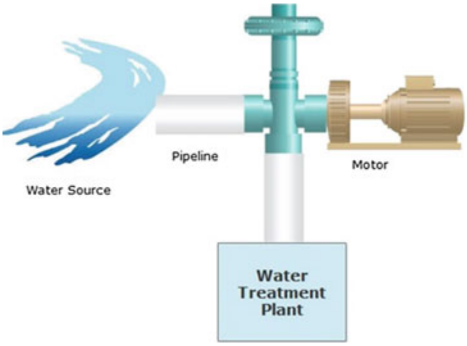
Fig. 16.1 Water supply system—overview

16.4 Results and Discussion

The strategic relationships between product and service components were analyzed in three parts. The first part is from the source to the water treatment plant. The second part is the water treatment plant to the reservoir tank. The third part is the reservoir tank to the end user. In each part, product and service components were identified and mapped. Following is the description of product–service system components and their mappings.

16.4.1 Source to Water Treatment Plant: Product–Service System

In this part, the major products are motor, pump, valves, pipeline including various pipe fittings, viz. elbow, flange, and couplings. Service components are motor winding, replacements of bearings, gear differentials, cleaning and lubrication, leakage maintenance of the pipeline. Figure 16.2 shows details of product and service components of this part.

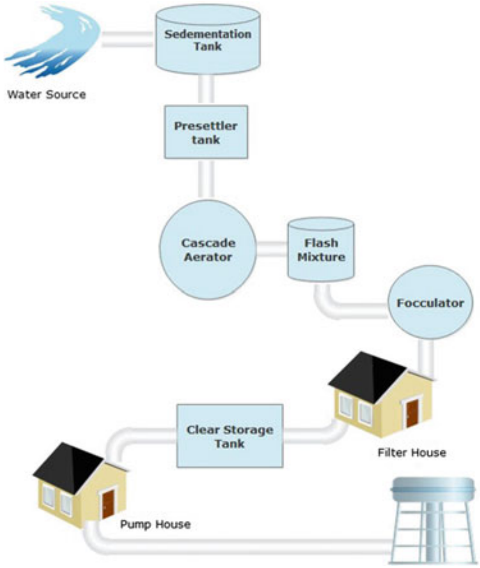


Particulars	Details
Motor	• 2 No. running 1 No. standby • KSB make: Mega Gc 100-200 model • Capacity: 175m³/hr , 45 kW, 60Hp • maximum Current: 72 amp • Voltage: 440V
Pipeline	• Diameter : 250 mm • length : 550 m • Material : Ductile
Service Components	• Pump : 2 years life KSB make • Valve : 18 months KVMC make

Fig. 16.2 Product–service system—source to water treatment plant

16.4.2 Water Treatment Plant to Reservoir Tank: Product–Service System

In this part, the product components are alum, motor, valves, pumps, shaft sleeves, bearings, toothed pinion, gears, chlorinator, etc. Service components are cleaning of algae, replacement of gear system, and breakdown maintenance of shafts. Figure 16.3 depicts the product–service system components in the filtration process of water treatment plant.



Section	Products	Services
Sedementation Tank	----	• Cleaning • Capacity 7.2 lakh liters
Presettler Tank	----	• Cleaning algae • manual cleaning
Cascade Aerator	----	• Cleaning algae • manual cleaning
Flash Mixture	• Alum dosage • Motor	• Bearings • Gear system • Toothed pinion
Focculator	• Valves • motor	----
Filter House	• Valves • Core sand • Gravels	• Cleaning filter bed
Pump House	• Pumps • Shaft protection sleep	• Bearings

Fig. 16.3 Product–service system—water treatment plant to reservoir tank

16.4.3 Reservoir Tank to End User: Product–Service System

In this part, the product components are pipeline including various pipe fittings, cooler, purifier, and push tap. The service components are leakage prevention and corrosion maintenance of pipeline, cleaning of overhead tanks at each establishment, preventive and breakdown maintenance of cooler and purifier. Figure 16.4 depicts the product and service components of reservoir tank to end-user part.

16.4.4 Mapping of Product–Service Components of Water Treatment Plant

The mapping was done for the water treatment plant considering the factors linked with product–service system of each section. Factors considered were service frequency, time for service, number of workers, lead for spare, shutdown during service, and skill required.

Table 16.1 shows the detailed mapping of product–service system. It was found that the flash mixture section is critical. It requires 24 h for service with high-skilled manpower. It also has 4 days lead time for spares. It was also observed that due to breakdown of the motor, flash mixture operation was carried out manually. It has been observed that flocculator section is also moderately critical. Therefore, a better product–service system design strategy is required in the aforesaid sections.

Following are the general observations made over the water treatment plant. Communication to any problems related to water is done through mail or telephonic conversation. People are working round the clock on different shifts to ensure smooth operation. The raw water contamination varies according to monsoon and non-monsoon seasons, measured based on turbidity. Whenever the turbidity is low, alum dosing is less. Although the water passes through units such as flocculators and settling tanks before passes through backwash sand filters. The cleaning of spade in pre-settler tank was manually carried out due to breakdown of the motor. Alum bricks are made into solution in chemical house and added to flash mixture. Further mixing has to be done by the motor. But it was observed that mixing of alum in flash mixture was done manually. Record for consumption of alum on daily

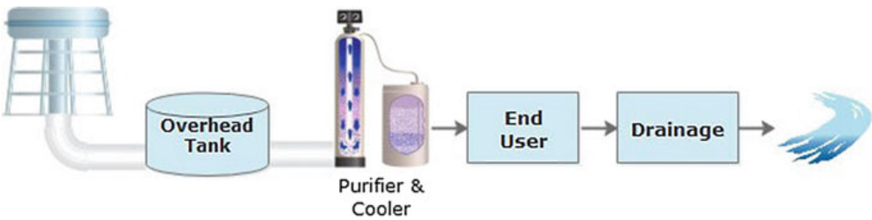


Fig. 16.4 Product–service system—reservoir tank to end user

Table 16.1 Products and service components of water treatment plant

Sections	Product–service components	Service frequency (in months)	Time for service (in hrs.)	No. of workers	Lead for spare (in days)	Shut down
Sedimentation tank	Cleaning spade	6	56	8	–	Yes
Pre-settler tank	Cleaning spade	6	4	3	–	Yes
Aerator	Cleaning algae	1	1	3	–	Yes
Flash mixture	Motor	4	8	2	4	Yes
Flocculator	cleaning	6	8	8	–	Yes
Filter house	Valves	12	40	5	7	No
	Filter bed	1	1	1	–	
Clear storage tank	Cleaning	6	8	8	–	Yes
Pump house	Shaft	48	16	3	90	Yes
	Sleep	24	16	3	90	
	Chlorinator	6	8	2	1	

basis is maintained properly. It was also observed that most of the products related to motor were worn out. Spares were not supplied on time. Cleaning of filter house has to be done every 6 months. It was observed that it was not cleaned properly on regular basis. This problem has occurred due to non-availability of third-party service provider. Our recommendation in this aspect is for application of system thinking to evolve a product–service system design strategy. Mapping of the product–service system discussed in this study can help in formulating an effective management strategy considering all the stakeholders and components of product–service system of water treatment plant.

16.4.5 Mapping of Product–Service Components of Cooler and Purifier

The mapping was done for water cooler and purifier section considering the factors linked with product–service system of each section. Table 16.2 depicts the mapping of product–service system components of cooler and purifier. It was observed that in most of the product–service components shutdown is necessary during service. It was also observed that it requires high-skilled manpower. Therefore, proper preventive maintenance policies are to be framed. It was also observed that records on service components for purifier and cooler were not maintained properly by the contractor. It was difficult to track for the specific product–service components placed on the individual purifier or cooler. Therefore, it is recommended to design a

Table 16.2 Product–service components of cooler and purifier

	Product–service components	Service frequency (in months)	Time for service (in hrs.)	Shutdown	No. of workers
Cooler	Capacitor	Depends on voltage	0.5	Yes	2
	Refrigerant	If leakage	3	Yes	2
	Fan motor	4 months	1.5	Yes	2
	Thermostat	4–5 years	0.5	Yes	2
	Push tap	Users	0.25	No	1
Purifier	RO membrane	1–2 years	1	Yes	2
	Cotton spun	3 months	0.67	Yes	2
	Filter candle	3 months	2	No	2
	Solenoid valves	6 months	1.5	Yes	2
	12 V PCB	Depends on voltage	1.5	Yes	2

computerized information system to streamline the preventive maintenance including optimization of inventory and schedule. From Table 16.2, attributes are: service frequency, time for service, shutdown during service, and number of workers.

Inventory and high skill are the characteristics for majority of product–service components. To provide necessary service high-skilled and a semiskilled labor is must in most of the situations. The maximum time required is 3 h to replace refrigerant, and the minimum time required is 0.25 h to replace push tap. Service frequency for these two products is unlikely (if leakage). Capacitor and 12 V PCB depend on voltage variations to get replaced. RO membrane and thermostat require more than a year for service frequency, and time required to replace product is 0.5–1 h. Therefore, purifier product is selected for improvising service and quality of product. Selecting purifier product depends on two reasons. First as service frequency to be minimized and is average compared to products of cooler. Second as time required to replace products of purifier consumes more time associated with products of cooler.

16.5 Quality Function Deployment (QFD)—Purifier

QFD is a popular quality method that is developed in the 1960s and the 1970s to address design quality challenges to meet better customers' expectations. QFD is a proven technique that is able to translate customer's requirements into design requirements [9]. Akao [10] defines QFD as a method for defining design qualities that are in keeping with customer expectations and then translating the customers' requirements into design targets and critical quality assurance points that can be used through production–service development.

A. Martins and E. M. Aspinwall has experimented with QFD method in development of product, processes and service together [11]. Knowledge management and QFD approach were employed to know customers' needs in a new product design development project in a mineral water company [12]. We also found a very interesting application of QFD in selection processes for supplier evaluation in a pharmaceutical company [13]. Effectively to meet customer's requirements, it is required to review the voice of the customer throughout the production–service development. The customer's requirements for water purifier include, viz. product components' longer life, spare parts size should fit correct, durability, use of better material, convenient packaging, less cost, no leakage, and provide installation services. The customer assigned a weight indicating relative importance of each demand. The ratings for the weight are among 1 to 5, with 5 being the most important demand. The quality characteristic for water purifier is classified into two parts. First part is product-related technical measures, viz. RO membrane, cotton spun, filter candle, solenoid valve, and 12 V PCB. Second part is

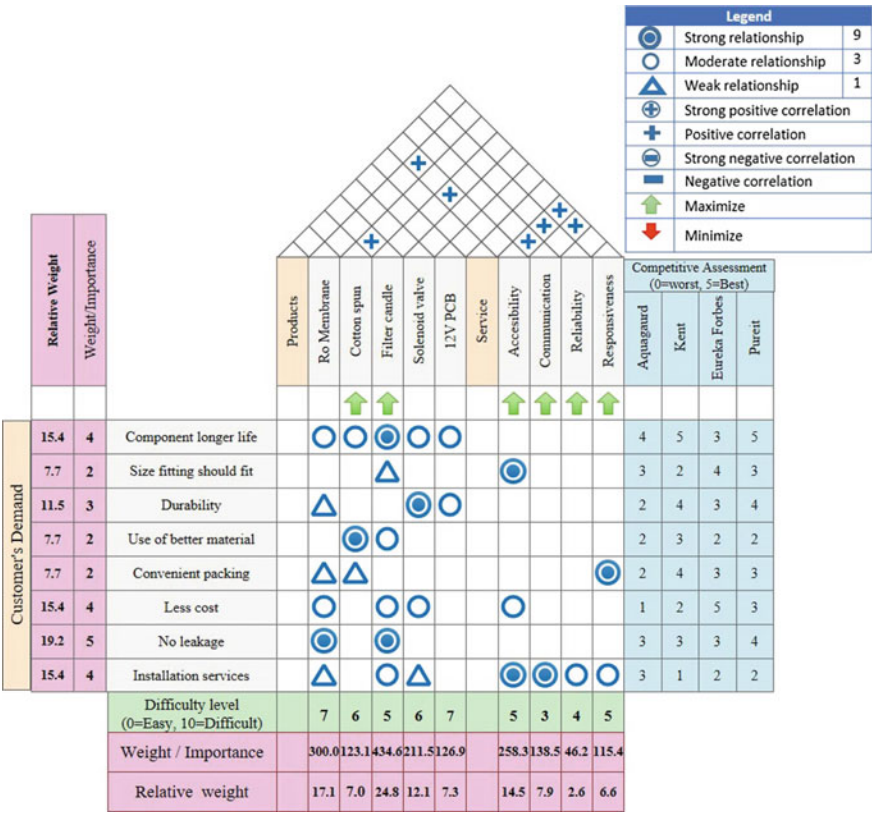


Fig. 16.5 House of quality 1 for the purifier

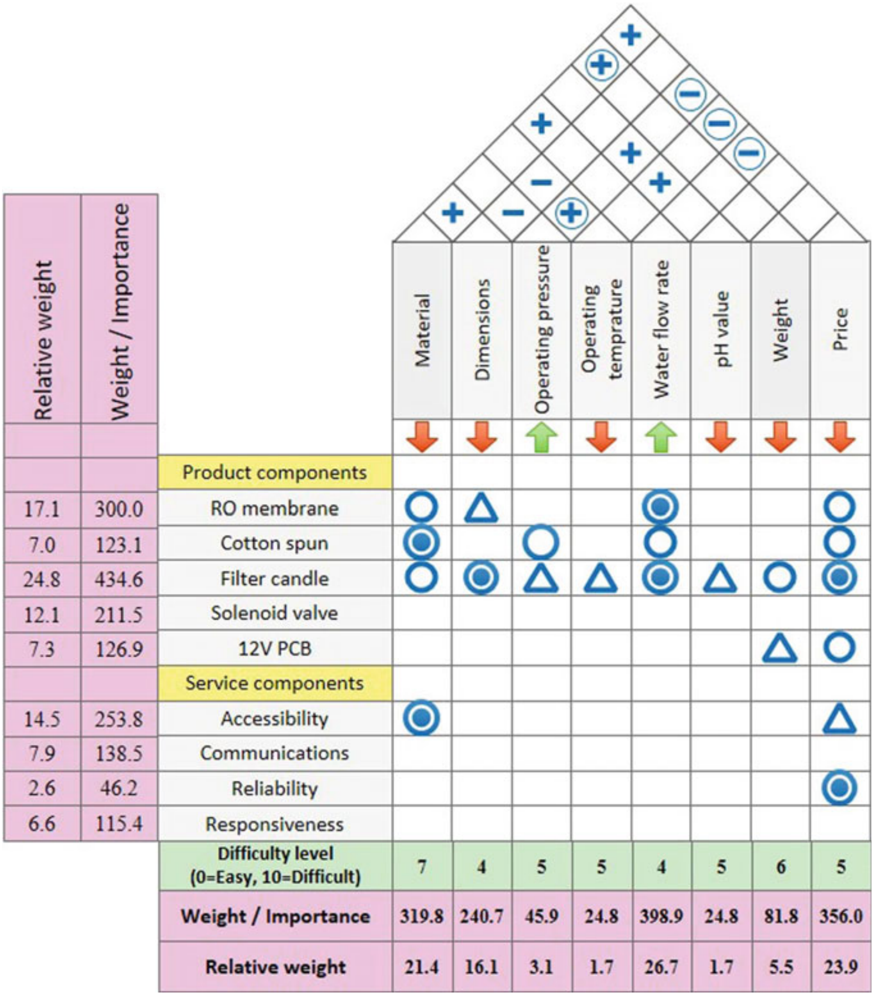


Fig. 16.6 House of quality 2 for the purifier

service-related technical measures, viz. accessibility of filters, communication, reliability, and responsiveness (Fig. 16.5).

The relationship between customer's requirements and functional requirements is developed for water purifier. The relationship is indicated as strong, moderate, and weak along with the associated amount and symbols. One of the customer requirements was leakage of water, which is a strong relationship with technical measures of filter candle on functional requirements.

To identify the interrelationship between each of the technical descriptors, correlation matrix is established, i.e., called the roof of house of quality. To identify the areas to concentrate on next design and to improve needs of customer, the competitive assessment is conducted for purifier product. From the technical descriptors the most important and need to be considered for actions plans: filter candle (434.6), RO membrane (300) and accessibility (253.8) house of quality 2 is the action plan for filter candle as depicted in Fig. 16.6. The technical measures for filter candle product include, viz. material, dimensions of filter candle, operating pressure and temperature, water flow rate, pH value, weight, and price. From the technical descriptors the most important and need to be considered for actions plans: water flow rate (398.9), price (356) and material (319.8).

16.6 Conclusion

The most significant elements in the water supply system were identified in the study. The interrelationships of product–service system of each sub-system of water supply system provided the opportunity for mapping. Mapping was done by using system organization technique. This method of mapping has been found to be effective. The HOQ interprets the voice of customer's into design requirements. Technical descriptors are prioritized based on customer's need and competitor's assessment. Thus, the first three quality characteristics should be prioritized that are the candle element, price, and accessibility of filters. This is a new design management strategy in product–service system in the context of water supply system within a community. The matrix developed for product–service system study will give a new approach to design method in this context. The study will benefit students and academicians involved in design of product–service system and design management.

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