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A Framework for Implementing Quality Function Deployment (QFD) For Utility Services

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Abstract: *This Survival of organizations has become necessary with fulfilling the needs of the customers. Quality function deployment (QFD) is an efficient tool to prioritize customer requirements and technical solutions followed by identification of relation among technical solutions. In this research, house of quality (HOQ) has been employed to develop framework for implementing QFD for utility services. The framework is based on relationship matrix, technical matrix and correlation matrix. The voice of customers (WHATs) data was collected from customer of utility services company through interviews via semi-structured questionnaire; whereas, the technical solutions (HOWs) were identified from experts working within the selected company through interviews. It had been identified from this research that 'new technology adoption' is the core of customer requirements solution. The innovation in the research is that little or no work has been reported which suggests the pathway to transform from single buyer model to wholesale competition model using QFD.*

Keywords: *House of quality (HOQ), Kano model, QFD, utility service, Voice of Customer*

I. Introduction

Electricity generation and distribution companies are facing severe problems due to oscillating fuel prices and abruptly increasing electricity demands. Technological advances and international competition have also exerted pressures on these companies. Since the customers are better aware of quality; therefore, the gratification of the customers has become the most important thing for the survival of the companies. Better planning, forecasting to balance load/supply, and new technologies for improving generation and distribution may lead to overcome these issues and to improve customer satisfaction.

Quality function deployment (QFD) is a method to identify problems, prioritize the solutions, and plan accordingly. QFD supports the philosophy of planning a final product or service by changing customer needs into technical aspects required to satisfy the needs of customers. It is an organized method of capturing the requirements of customers and translating them into technical requirements. Consequently new targets are proposed for designers and manufacturers which have to be achieved for fulfilling the needs of customers. Correct implementation of QFD can improve the knowledge of engineering, production and development time [1]. There are many ways of capturing the requirements of customers including gathering requirements through questionnaires and observations. House of Quality (HOQ) is one of the tools of QFD, which interprets the voice of the customers into the specifications of products.

In this paper, a framework based on QFD for utility services has been proposed. This framework provides the guidelines to a utility service company and by implementing these guidelines, the satisfaction level of customers may be improved. This paper progresses as follows: literature review of the practices is presented in the next section; this is followed by illustration of methods and procedures. Section 4 discusses the development of framework and finally conclusions drawn in Section 5.

II. Literature Review

Quality function deployment (QFD) is a methodology for enhancing the quality of new products or services so that the satisfaction of customers can be enhanced [2]. QFD has also been developed into a technique for controlling the design process [3]. It has been argued that house of quality (HOQ) is the main tool of QFD [4]. House of quality matrix (HOQ) is a correlation between customer needs and design requirements. It interprets the demanded service quality of a product into real or vague service quality characteristics [5]. HOQ consists of six stages namely (i) requirements of customers (HOW), (ii) technical solutions (WHO), (iii) relationship matrix between customer requirements and technical solutions (relationship matrix), (iv) correlation among technical solutions correlation matrix, (v) technical matrix and (vi) planning matrix [6]. There are many forms of QFD that are related to different domains; hence HOQ can be assembled in numerous configurations. However, this originates from customer's needs identification because other five stages of the process depends

on it [7]. The standard framework of HOQ is shown below in fig 1. Since customer requirements is the prime focus of the house of quality; therefore, it has become necessary for the organization to tune up their facilities according to the requirements of the customers. Customer requirements are classified into three types namely (i) expected requirements, (ii) exposed requirements, and (iii) exciting requirements. Expected requirements are the basic requirements which customers usually do not pay attention but their absence make them dissatisfied. Exposed requirements are true needs of customers and are collected by inquiring them. Finally the exciting requirements are those whose presence make customers excited [8]. These requirements can be analysed through Kano model which is presented in fig 2.

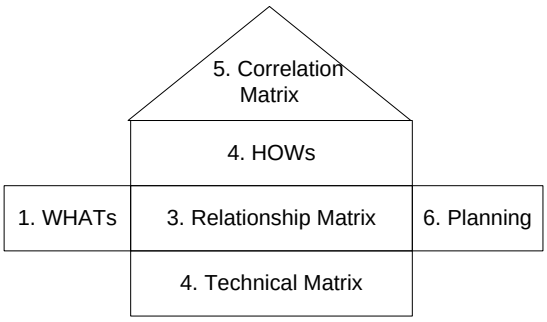


Figure1. House of Quality

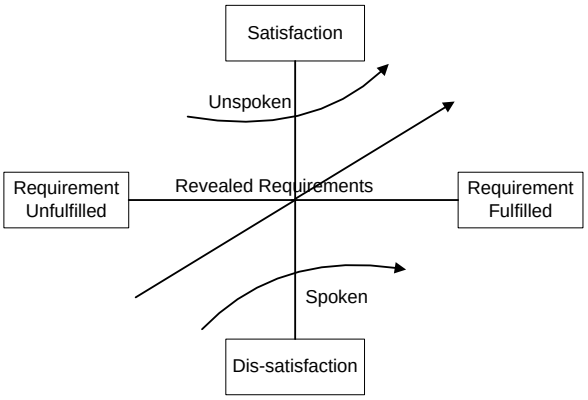


Figure2. Kano model

QFD has been deployed in variety of applications. For example, Das & Mukherjee [9] applied QFD to analyse the positive and negative impacts related to the tourism industry and then suggesting solutions for overcoming them. It has been applied in hospitals to enhance hospital services [10], in IT industray to improve the design quality of websites [11] and in green manufacturing system [12]. Sohn & Ki So [13] claimed that the value of quarter-life atmosphere in Korea has been improved through QFD.

Researchers have also implemented QFD in utility services [8, 14-17]. Delgado, Saraiva and de Almeida [14] used QFD to improve the electrical power delivery in electrical power sector of Portugal. Anwar, Masud, Abedin, & Hossain [8] deployed QFD on Bangladesh power sector and identified that quality of service in an electrical supply company can be enhanced. QFD also gave solution to the companies who distribute and commercialize electricity for identifying the focal point of an organization in Spain [16].

There are four power liberalization models namely (i) monopoly model, (ii) single buyer model, (iii) wholesale competition model, and (iv) wholesale/retail competition model [18]. Developing countries like Pakistan, who are relying on monopoly or single buyer models, are facing severe load shedding issue. Switching from single buyer model to wholesale competition model and wholesale/retail competition model has the potential to overcome the problems faced by these countries. This switching is a challenging task and cannot be attained without customers' requirements identification and their fulfilment through proper planning. Since these developing countries have acute shortage of electricity, there is a need to develop a roadmap for customer satisfaction. Little or no work has been reported in literature to transform from single buyer model to wholesale competition model using QFD. Therefore, this research aims to propose a QFD framework for utility services in developing countries.

III. Research Methodology

Since transformation from single buyer model to wholesale competition model using QFD has not been explored for developing countries; therefore, this research falls under the category of exploratory in nature. Qualitative approach including interviews via semi structured questionnaire was considered to be most appropriate for this research. The research is composed of 7 stages. It initiated with understanding of QFD for utility services. A detailed literature review related to QFD, HOQ and implementation of QFD in developing countries was carried out in stage 1. In next stage, the case study company providing utility services was selected for HOQ development. The detailed information of company has been provided in Section 3.1. The 3rd stage was identification of customer requirements through interviews via semi structured questionnaire. 100 questionnaires were distributed among customers of selected company; out of which 83 respondents participated in interviews. The participants were selected randomly and it was believed that the participants were true representative of population. Likert scale from 1-5 was used in questionnaire. The questionnaire was designed based on the factors identified from literature review and experts opinion. The detailed analysis and results of the questionnaire have been explained in Section 3.2. Stage 4 was the identification of technical solutions of problems faced by customers. 30 industrial experts working in the selected company were contacted. The experts were asked to explore their knowledge and experience and propose the technical solution corresponding to each problem, so that each demand of the customer can be met and relationship may be established between customer requirements and technical solution. The experts were specialists in design, development, planning and human resources services management with the working experience ranging from 8 to 25 years. These experts were identified from the focal person working in the selected company. The same experts were requested to develop relationship matrix and correlation matrix (stage 5). Based on relationship matrix and weights of 'voice of customer' obtained by regression analysis, technical solutions were prioritized in stage 6. Finally the QFD framework based on relationship matrix, technical matrix and correlation matrix was developed in stage 7.

IV. Case Study: IESCO

The utility services company selected in this research is electric supply corporation (IESCO) located at Islamabad, Pakistan which was formed in 1998. Its head office is located in Islamabad. The Area Electricity Board was established through adjustments in Water and Development Authority (WAPDA) act during 1981. The main function of IESCO is to sell and distribute electricity in the main cities of Punjab and Kashmir. Millions of people are being served by IESCO directly. Government of Pakistan approved refurbishing of the power sector of WAPDA under the power sector restructuring program; as a result twelve commercial bodies were established. IESCO was formed to achieve following objectives: (a) to improve customer satisfaction, (b) to lessen the line losses, (c) to rise income generation, and (d) to remove bribery issues in the corporation. The planned and unplanned load shedding is the major problem faced by the customers. The related problems faced by the customers have been explained in next section.

Voice of Customers: What Linear regression analysis was employed to analyze the responses of questionnaires. Equation 1 demonstrates a simple linear regression model.

$$y = \beta_0 + \beta_1 \chi + \varepsilon \quad (1)$$

Where β_0, β_1 are constraints of the model, and ε is an arbitrary variable. Equation 2 shows the simple linear regression equation.

$$E(y) = \beta_o + \beta_1 \chi + \varepsilon \quad (2)$$

13 customer requirements were identified in the interview with the customers of selected companies. Customer requirements with their average percentage have been provided in table 1. Minitab Software was used for the regression analysis. After detailed analysis, the weights of customer requirements had been calculated. Customer requirements with weights are also given in table 1.

Table1. Customer requirements (Average percentage and Weights)

Sr.	Customers' Requirement (WHATs)	Average Percentage	Weight
1	Application of electricity meter through internet	81	43
2	Minimum installation time of electricity meter if malfunctioning occurs	47	43
3	Reliability of electricity meter	58	34
4	Accurate meter readings	51	34
5	Fair billing system of IESCO	56	34
6	Monthly electricity bill on time	74	34
7	Efficient customer services of IESCO	56	34
8	Positive attitude of technical staff	53	34
9	Replacement of meter equipment when needed	46	34

10	Information regarding discontinuation of electricity services through internet, telephone, mobile message	92	34
11	Uninterrupted electricity supply	87	34
12	Load shedding schedule information through internet, telephone ,TV, ,newspaper	77	34
13	Generation of electricity through coal, hydel, thermal, diesel and alternate energy sources (solar/wind/bio gas)	73	34

Voice of technical squad: How the stage 4 of QFD was the identification of the voice of technical squad. In this stage, the technical experts were requested to propose the solution of each requirement of customers, which was named as technical descriptor. The technical descriptors related to customer requirements have been provided in table 2. Each technical descriptor fulfills one requirement of the customer. For example, the experts were requested to propose solution for customer requirement "accurate meter reading". The technical professional proposed number of solutions with more emphasis on "new technology adoption".

Table2. Technical descriptors against customers' requirements

No.	Customer requirements	Technical descriptors
1	Application of electricity meter through internet	Authorization of existing customer services
2	Minimum installation/replacement time of electricity meter if malfunctioning occurs	Demand and supply balancing
3	Reliability of electricity meter	New static and accurate meters
4	Accurate meter readings	New technology adoption
5	Fair billing system	Vicinity based single server
6	Monthly electricity bill on time	Decentralized computerized system
7	Efficient customer services of IESCO	ERP/SAP solution
8	Positive attitude of technical staff	Focusing on employees
9	Replacement of meter equipment when needed	Error and prevention recovery
10	Information regarding discontinuation of electricity services through internet, telephone, mobile message	Effective customer services
11	Uninterrupted electricity supply	Load balancing
12	Load shedding schedule information through internet, telephone, TV, newspaper	Online marketing
13	Generation of electricity through coal, hydel, thermal, diesel and alternate energy sources (solar/wind/bio gas)	Use of alternate fuel

Matrix between customer requirements and technical descriptor: Relationship matrix in this stage, professionals of selected company were asked to relate customer requirements with technical descriptor identified in stage 3 and 4. This part of the QFD was more challenging and time consuming because professionals were asked to explore their knowledge and experience so that each demand of customers could be met and relationship could be established between WHATs and HOWs. In order to fulfill this purpose, a series of interviews were conducted from the professionals of IESCO.

Numerical grading method had been used for defining the relationship between WHATs (Voice of the customers) and HOWs (Technical descriptors) (9= a strong relationship, 3= a medium relationship, 1 = a weak relationship and 0 = no relationship) [4].

Correlation among technical descriptors: Correlation matrix To identify the dependency of one technical descriptor over other descriptors, correlation matrix was prepared in stage 5. The matrix was filled by 30 experts. The dependency among descriptors was measured as strong positive, positive, negative and strong negative. The symbols used for correlation has been provided in fig 3.

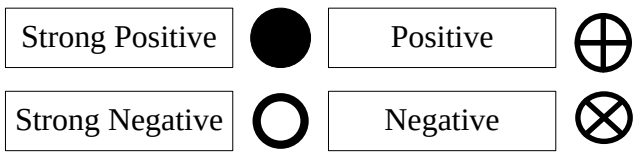
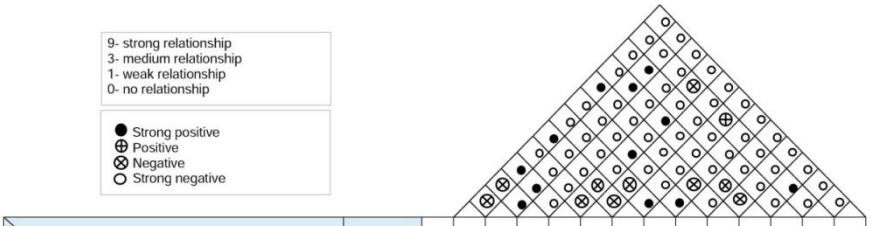


Figure3. Symbols with meaning

Technical descriptors prioritization matrix: Technical matrix The technical matrix prioritizes the technical descriptors based on weights assigned in relationship matrix. The matrix is helpful for companies to identify most sensitive technical descriptors for future planning. Technical descriptors with their absolute weights, relative weights and priorities are given in fig 4 and table 3. Based on the absolute weights, the technical descriptors were prioritized in the order of level of sensitivity. It was learnt that 'new technology adoption' appeared to be the most sensitive technical descriptor with relative weight of 12.36%, followed by 'effective customer services', 'authorization of existing customer services' and 'focusing on employees'. Technical

descriptors like 'load balancing', 'vicinity based single server' and 'use of alternate fuel' came out least sensitive in the study.



WHATs / HOWs		Technical Descriptors	Authorizaion of existing Customer Services	Demand and Supply Balancing	New static and accurate meters	New Technology Adoption	Vicinity Based Single Server	Decentralized Computerized System	ERP/ SAP solution	Focussing on Employees	Error and Prevention Recovery	Effective Customer Services	Load Balancing	Online Marketing	Alternate fuel
Customer Requirements		weight													
Application of new electricity meter through internet		43	9	0	0	0	0	0	0	0	0	9	0	3	0
Minimum installation/replacement time of electricity meter if mulfunctioning occurs		43	0	9	0	0	0	0	1	3	3	3	0	0	0
Reliability of electricity meters		34	0	0	9	0	0	0	0	1	1	0	0	0	0
Accurate meter readings		34	0	0	9	9	1	1	1	0	1	1	0	0	0
Fair billing system of IESCO		34	0	0	1	9	3	1	0	0	1	1	0	0	0
Monthly electricity bill on time		34	0	0	0	9	3	9	1	0	0	0	0	0	0
Efficient customer services of IESCO		34	3	0	0	3	3	9	9	9	3	3	1	0	0
Postive attitude of technical staff		34	0	0	0	0	0	0	0	9	0	0	0	0	0
Replacement of meter equipment when needed		34	0	9	0	0	0	0	0	0	3	0	0	0	0
Information regarding discontinuation of electricity services through internet, telephone, mobile message		34	9	0	0	0	0	0	1	0	1	9	0	9	0
Uniterrupted electricity supply		34	0	0	0	0	0	0	0	0	0	0	9	0	0
Loadshedding schedule information through internet,telephone,TV, newspaper		34	0	0	0	0	0	0	0	0	0	0	0	9	0
Generation of electricity through coal, hydel, thermal, diesel and other alternate energy resources		34	0	0	0	0	0	0	0	0	0	0	1	0	9
Absolute weight			**795**	**693**	**646**	**1020**	**340**	**680**	**451**	**775**	**469**	**992**	**340**	**741**	**306**

Figure4. QFD Matrix

Table3. Technical descriptors (Absolute weights, Relative weights and Priorities)

No.	Technical descriptors	Absolute weight	Relative weight	Priorities
1	Authorization of existing customer services	795	9.63%	3
2	Demand and supply balancing	693	8.40%	6
3	New static and accurate meters	646	7.83%	8
4	New technology adoption	1020	12.36%	1
5	Vicinity based single server	340	4.1%	11
6	Decentralized computerized system	680	8.24%	7
7	ERP/SAP solution	451	5.46%	10
8	Focusing on employees	775	9.39%	4
8	Error and prevention recovery	469	5.68%	9
10	Effective customer services	992	12.02%	2
11	Load balancing	340	4.1%	11
12	Online marketing	741	8.98%	5
13	Use of alternate fuel	306	3.70 %	12

V. QFD Framework For Utility Services

The QFD framework is based on relationship matrix, technical matrix and correlation matrix. The developed framework informs decision makers about the most sensitive and least sensitive descriptors. The decision makers may identify the priority of a single descriptor and improve the customer services accordingly.

The correlation matrix may also help to further explore less sensitive technical descriptors which are sensitive to selected descriptor.

The technical descriptors in framework have been arranged in three layers depending upon their relative importance identified from technical matrix. The wheel flows inward and outwards on the basis of importance of technical descriptors. The inner layer constitutes the most important technical descriptor. The intermediate layer contains technical descriptors which are positively related with technical descriptor available at inner layer. Finally, the outermost layer has been developed constituting the technical descriptors strongly positively related to the neighboring technical descriptors at intermediate layer. The developed QFD framework has been represented in fig 5. 'New technology adoption' was the highest priority technical descriptor and thus constitutes the innermost layer. In correlation matrix, New technology adoption was strongly positively related to (i) effective customer services, (ii) authorization of existing customer services, (iii) Focusing on employees, and (iv) demand and supply balancing; therefore these technical descriptors have been placed in intermediate layer. As far as outer layer is concerned, online marketing was strongly positively related to effective customer services; therefore, it was connected adjacent to effective customer services. Similar approach was adopted to place the technical descriptor in the outer layer.

The arrangement of technical descriptors in the manner proposed in framework helps the decision makers to easily identify solution of problems. For example, if the management wants to fulfill the customer requirements through new technology adoption; there are four available tracks namely (i) effective customer services, (ii) authorization of existing customer services, (iii) Focusing on employees, and (iv) demand and supply balancing. If the management identifies effective customer service which was the second most priority solution of customer requirements, the top management needs to improve online marketing services. Similarly other tracks may be followed. The detailed description of intermediate and outer layer technical descriptors has been provided in Section below.

Authorization of existing customer services and Decentralization

Authorization of customer services is directly linked with decentralized computerized system, and error and preventive recovery. For example, if new customer wants an electricity connection, his least priority would be manual application. From the survey, it was identified that most customers prefer to apply new connection through online services. Similarly authorization of existing customer services my prevent errors.

One of the major complaints of the customers was late billing reception. The solution proposed by the experts was arrangement of decentralized computerized system for printing and posting of bills. Most of the organizations prefer decentralization because it has many advantages like project managers are close to the projects and they take decisions on their own rather than obeying higher management [19]. Moreover, decentralization reduces differences among a region and a central authority [20].

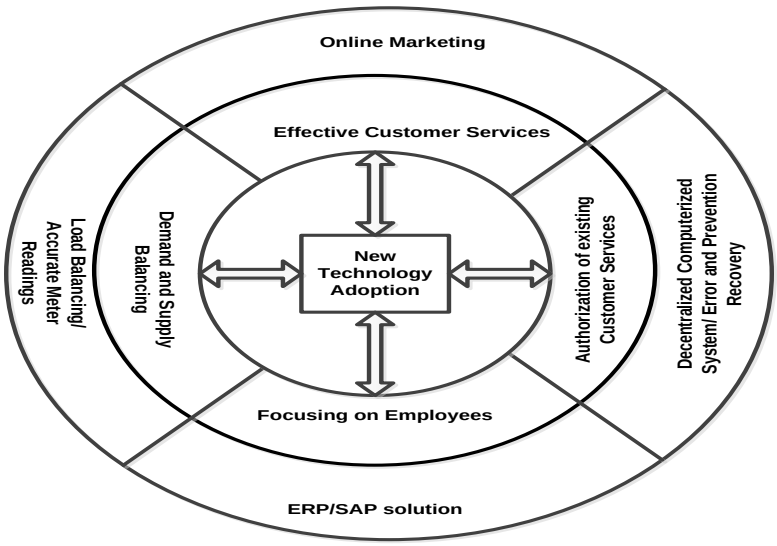


Figure5. QFD-Framework for utility services

Effective customer services and Online Marketing From the outcome of the questionnaires, it was revealed that customer showed their concern regarding disconnection of electricity without prior information. To fulfill this demand, the professionals proposed central call centre /customer services at sub-divisional level. In this way, every common man could have an access to the services centers easily.

From the survey, it had also been noticed that people wanted to know about the load shedding schedule so that they could manage their work accordingly. Digital marketing, cross media marketing and direct marketing are proposed solutions for these problems [21].

Focusing on employees and ERP/SAP

It has been highlighted by the experts that focusing on employees leads to new technology adoptions. Rewards on performance, incentive plans, recognition of hard working and promotions activities improve employees' performance and ultimately results in new technology achievement [22]. The need of efficient resource utilization was identified through questionnaire. System management solutions including ERP and SAP were proposed by the experts, which have the capability to improve employee performance, efficient customer services and improve time related issues.

Demand/supply balancing, Load balancing and accurate meter reading

Another major problem highlighted by the customers was unplanned load shedding. Experts informed that inappropriate demand/supply balance and load balance are the major contributors of load shedding. Inappropriate planning, policies, inefficient energy production and distribution strategies and lack of resource utilization are the main reasons of clients' dissatisfaction. The problem can be dealt with rehabilitation of load balancing and bridging the gap between demand and supply.

Timely installation or replacement of malfunctioning meter was also leading to customer dissatisfaction. Slow/ nonresponsive customer service was the major reasons behind this problem. Whenever they complaint arrives, the customer receive the information of non availability of the appropriate person for meter installation or the organization had run short of meters. The professionals of IESCO informed that the complex purchase procedure of new electricity meters is the root cause of problem. Therefore, it was recommended that sufficient quantity of electricity meters should be available at sub-divisional level and IESCO should adopt easy methods for purchasing of materials.

VI. Conclusion

In this research, a framework for implementing QFD for utility services has been proposed. An electric supply corporation (IESCO) was selected to develop the framework. The framework is based on customer requirement, technical descriptors, relationship matrix, technical matrix and correlation matrix, which are components of HOQ.

Linear regression analysis was used to weight the customers' requirements. The study exposed thirteen requirements of the customers that were needed to be addressed. Thirteen technical descriptors were proposed accordingly by the experts to accomplish the customer requirements. Based on technical experts judgements, 'new technology adoption' was found to be the highest priority technical solution, followed by effective customer services, focusing on employees and online services. Finally, a QFD framework has been proposed consisting of three layers. The inner layer constitutes the most important technical descriptor. The intermediate layer contains technical descriptors which are positively related with technical descriptor available at inner layer. The outermost layer constitutes the technical descriptors strongly positively related to the neighboring technical descriptors at intermediate layer.

The developed framework informs decision makers about the most sensitive and least sensitive descriptors. The decision makers may identify the priority of a single descriptor and improve the customer services accordingly. The arrangement of technical descriptors in the manner proposed in framework helps the decision makers to easily identify solution of problems.

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