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# ENHANCING SERVICE EFFICIENCY IN UTILITY ORGANIZATIONS THROUGH QUALITY FUNCTION DEPLOYMENT

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## ABSTRACT

Quality Function Deployment (QFD) is a powerful approach for establishing a strong relationship between a product or service and customer needs. It focuses on capturing the voice of the customer to enhance their satisfaction. In today's competitive landscape, organizations must meet customer needs to thrive. This research focuses on utility-imparting organizations and aims to enhance customer satisfaction and service efficiency through the development of a correlation matrix. The study proposes an inductive framework and evaluates it using typical QFD techniques. Specifically, the research utilizes the House of Quality (HOQ) to improve organizational efficiency and customer satisfaction. The HOQ identifies key quality indicators by analyzing the relationship between customer needs (WHATs), and technical solutions (HOWs), as well as between different HOWs. The results of the HOQ analysis highlight the most crucial factors for improving service efficiency: effective customer service, a competitive and focused organization, accurate billing meters and methods, precise meter readings and billing, and prioritization of emergency response. The findings provide valuable guidelines for improving the efficiency of utility energy services.

**Keywords**: Quality function deployment, house of quality, voice of customer, technical solution, customer satisfaction, utility organization.

## INTRODUCTION

Quality is essential for long-term success and durability of both products and services. It plays a crucial role across various sectors from manufacturing to service industries, including utility-providing organizations (Sahney et al., 2003). However, the definition of quality can vary based on individual preferences. To ensure a product or service's success, it is vital to translate customer needs and desires into the company's language (Bouchereau & Rowlands, 2000). Quality Function Deployment (QFD), developed by Yoji Akao, Shigeru Mizuno and Dr. Tadashi Yoshizawa, is a tool designed to integrate quality into the service or product delivery process by meeting customer needs (Al-Aomar & Al-Meer, 2012; Mazur, 1996). QFD is a process-oriented design method that facilitates the translation of customer requirements into actionable steps and integrates these findings into the development process. Originating in Japan in the 1960s, QFD emerged as Japanese industries shifted from merely copying and imitating products to developing novel products. It was conceived during a period of rapid growth in the Japanese automobile industry and was initially known as total quality control (Pheng & Yeap, 2001). QFD ensures that customer needs and requirements drive product design and production processes (Chan & Wu, 2005). As a planning tool, QFD helps achieve customer demands and provides a framework for designing and evaluating products. When implemented effectively, QFD can enhance engineering knowledge, productivity and reduce development time (Govers, 1996).

Energy crises are significant challenges for many developing countries. For instance, Pakistan has been grappling with energy shortages for an extended period. This ongoing crisis has severely impacted the economic and led to public dissatisfaction due to frequent electricity and gas load shedding. The Sui Gas field in Sui, Baluchistan is the primary source of natural gas in Pakistan. The distribution of gas in Pakistan is managed by two public utility companies: Sui Southern Gas Company Limited (SSGCL) and Sui Northern Gas Pipelines Limited (SNGPL). SNGPL serves over 6.5 million consumers across various sectors (SNGPL, 2019). Quality Function Deployment (QFD) is particularly well-suited to evaluate SNGPL's services from the customers' perspective. By translating customer needs into technical specifications, QFD helps ensure that these needs are met effectively. QFD facilitates a shift from the outdated mindset of "we know best what the customer wants" to a more customer-focused approach of "let's hear the voice of the customer." This approach empowers organizations to proactively address quality issues instead of merely reacting to customer complaints (Thakkar et al., 2006).

The automotive industry adopted QFD in the mid-1970s, with Toyota leading the way in implementing this method. The application of QFD, which includes quality tables, was first implemented at Kobe Shipyard, Mitsubishi Heavy Industries Ltd., in Japan in 1972. Recently, QFD has been effectively applied in various fields, including knowledge system selection (Li et al., 2014), green building evaluation (Ignatius et al., 2016), bike-sharing project evaluation (Tian et al., 2018), and technical attribute prioritization (Wang et al., 2020). However, the development of House-of-Quality (HoQ) measures specifically to address the energy sectors remains underexplored. This research focuses on the energy sector, particularly Sui Gas, to identify customer requirements and responses in relation to technical product characteristics. It evaluates how QFD can be a key resource for enhancing customer satisfaction. This study aims to provide guidelines for SNGPL to improve efficiency and service quality by utilizing QFD as a tool to meet customer demands.

## LITERATURE REVIEW

### Quality Function Deployment

Quality function development (QFD) is a method used to gather the voice of the customer from the market and integrate it into the design process to ensure an authentic and effective product or service design (Masui et al., 2003). According to Djekic et al. (2017), QFD is a method for creating quality designs that meets customer needs by interpreting these requirements and translating them into design targets, incorporating major quality assurance points throughout the construction phase. Lam and Dai (2015) define QFD as planning and development method for structured products or services. It helps development teams clearly identify customer desires, and assess the proposed product or service's capabilities in fulfilling these requirements. By converting customer requirements into technical language, QFD aims to enhance customer satisfaction through careful planning and development. QFD is a flexible system that ensures company design requirements (DRs) are met by translating customer requirements (CRs) at each phase of product development, starting from design to manufacturing and distribution (Lam & Bai, 2016),. The present study applies QFD systematically to identify and address bottlenecks in the design of an assistive device. A basic tool widely used in QFD is the house of quality (HOQ). QFD encompasses four stages: product planning, parts design, process planning and process control planning. Each stage utilizes a relationship matrix known as the house of quality (HOQ) to facilitate these processes (Wu et al., 2020). QFD enables the grouping of items with similar characteristics, thereby creating flexible opportunities across various scenarios (Geum et al., 2012). The matrixes within the HOQ typically include: (i) customer needs and quality characteristics, (ii) product or service features, and (iii) quality characteristics.

The voice of customer is a crucial concept in QFD, defining what aspects (WHATs) need to be enhanced in a product or service. QFD not only helps in accurately identifying customer demands but also enhances the reliability and quality of services and optimizes product design while reducing costs (Zaim et al., 2014). Additionally, QFD's advantage lies in its structured representation and physical deployment, using tools, techniques, statistics and graphs to quantify quality (Hassani et al., 2018). QFD has broad applications across various fields. It has been used by engineers and designers in eco-design challenges, green supply chain management, e-waste supply chain networks, medical fields, service and manufacturing industries, systematic innovation, quality management, and even in educational services (Ghosh et al., 2014; Goharshenasan et al., 2022; Kasaei et al., 2014; Liu et al., 2016; Popoff & Millet, 2017; Singh & Rawani, 2018; Sivasamy et al., 2018; Van et al., 2018; Wang, 2017; Yazdani et al., 2020). SWOT, the balanced score card (BSC) and QFD are all critical indicators for strategy development. SWOT and BSC serve as input for QFD and are essential for developing strategies. The balance scorecard (BSC) aids in defining the WHATs of customer needs in the HOQ, while the value chain analysis (VCA) determines the HOWs for technical solutions (Hassani et al., 2018). The VCA and BSC model act as performance management tools, designed to address the constraints of traditional performance measurement systems (Clegg & Tan, 2007; Dwivedi et al., 2018).

Total quality function deployment (TQFD) is an advanced model of QFD that helps to translate customer feedback into actionable insights, fostering innovations and agility in services (Sivasamy et al., 2018). The C-shaped QFD 3D Matrix is used to prioritize both process characteristics and performance aspects of customer needs concurrently (Hassani et al., 2018). Recent advancements include an integrated QFD approach for selection and evaluation criteria (Van et al., 2018), and Enterprise-QFD, which can be

integrated with various methodologies to investigate customer requirements (Özdağoğlu & Salum, 2009). The Markovian-QFD approach effectively tracks changing customer priorities, enhancing QFD (Asadabadi, 2016). A study by Ahmadzadeh et al. (2021) introduced a multi-phase QFD model, identifying IT infrastructure, organizational structure, and top management support as key indicators. Additionally, Fargnoli et al. (2021) explored the "soft side" of QFD, focusing on prioritization of customer requirements in the food sector. QFD is also valuable for material selection and design concepts (Marini et al., 2016).

The QFD process is divided into four phases (Jaiswal, 2012; Wu et al., 2020). These phases include: i) Product Planning: This phase involves the creation of the house of quality, which aligns customer needs with product features. (ii) Product Design: This phase focuses on translating technical needs to product development. (iii) Process Planning: This phase aims to achieve the key characteristics of the product through detailed planning. (iv) Process Control: This phase involves developing plans to manage and control operations. Each phase is represented through a matrix chart, often referred to as "houses," which illustrate the entire system life cycle. Each house corresponds to a specific stage of the QFD (Gharakhani & Eslami, 2012; Wu et al., 2020). Although QFD has numerous applications across various fields, research on its application in the gas sector is limited. Therefore, this research focused specifically on the gas supply service sector.

**House of Quality**

House of quality (HOQ) is the central element of quality function deployment (QFD), serving as a bridge between customer demands (WHATs) and technical specifications (HOWs) (Maritan, 2015). Its name derives from its house-like structure, which helps illustrate how a product or service meets customer desire. By using correlation and relationship matrices, the HOQ effectively stores, produces, and compares information, enhancing cross functional integration within organizations (Mullane et al., 2019).

The HOQ consists of six phases: a) Customer Attributes or Demands (WHATs): This component focuses on capturing what the customer really wants and their preferences, irrespective of the designers' perspective. b) Competitive Assessment or Planning Matrix: This matrix compares different competing technologies and highlights opportunities for improvement. c) Technical Measure or Engineering Attributes (HOWs): This section outlines the technical requirements, also known as the "voice of an organization," detailing how changes can be implemented based on customer requirements. It ensures that the defined product is measurable, and that engineering characteristics align with customer perceptions. d) Relationship Matrix between WHATs and HOWs: this matrix known as the deployment matrix, shows the impact of each engineering requirement on customer attributes. It uses symbols or numbers to represent these relationships. e) Technical Correlation Matrix: This matrix represents the interactions between HOWs (engineering characteristics) indicating positive or negative interactions through symbols, while keeping other attributes constant. f) Technical Matrix or Target Value: This component ranks technical requirement priorities in descending order for product design or improvement. It summarizes basic data reflecting customer opinions and identifies strategic opportunities (Ramírez et al., 2017; Shrivastava, 2016). To effectively implement the HOQ, it is crucial to start with the customer view, as the success of subsequent phases depends on this foundational step (Shrivastava, 2016).

**KANO Model**

The Kano Model is a technique used to identify and categorize different types of customer desires and expectations (Lo et al., 2017). It is a vital tool QFD, developed by Kano, Seraku, Takahashi, and Tsuhi in 1984. The model classifies and prioritizes customer requirements based on their impact on customer satisfaction. It helps address customer that QFD may not fully identify, playing a key role in guiding producers' decisions regarding capacity allocation in product design to fulfill customer desires (He et al., 2017). For instance, Sabioni et al.(2020) utilized the Kano model to align engineering essentials with consumer requirements and satisfaction, aiming to bridge the gap between customer requirements and product configuration. Hou et al. (2019) focused on capturing varying feature characteristics through different phases of evaluation to enhance new product design using the Kano model. The model includes five categories: Attractive, One-dimensional, Must-be, Reverse, and Indifferent (Madzík, 2018).

**Voice of Customer**

The Voice of customer (VOC) process is essential to accurately capture and describe customer needs and requirements for a product or service. Market research techniques help organize and prioritize customer desires in relation to various alternatives. VOC is typically conducted at the start of launching a new product, process or service to ensure that customer wants are fully understood and addressed (Aguwa et al., 2017). Since customer voices vary from person to person—even within a single organization, where there are various perspectives such as those of the procuring organization, the employer, and secondary or maintenance organizations—it is crucial to acknowledge and integrate these diversified inputs to create successful products or services (Crow, 1994).

**QFD for Utility Services**

Previous research on QFD has predominantly focused on electricity companies within the utility sector. Anwar et al. (2010) applied QFD to DESCO Electricity Company to improve its service quality using the house of quality matrix. Similarly, Jahanzaib et al. (2016) utilized QFD methodology at IESCO Electricity Company. Delgado et al. (2007) examined the electric power delivery sector in Portugal and concluded that QFD methods significantly enhanced electrical power delivery. According to Royo et al. (2005), QFD supports the identification of key focal points and provides solutions and guidelines for customer satisfaction in electric distribution companies. In contrast, current research shifts focus to the gas sector, a crucial energy sector of utility services in Pakistan. This study specifically examined SNGPL, a gas supply company in Pakistan, to evaluate and identify the advantages of applying QFD methodology within the gas sector. In Pakistan, the Sui Gas field, located in Sui, Balochistan, is the largest natural gas field. Natural gas in Pakistan is transmitted and distributed by two major public utility companies: Sui Southern Gas Company Limited (SSGCL) and Sui Northern Gas Company Limited (SNGPL). SSGCL handles the distribution and transmission of natural gas in the southern part of Pakistan, from Sui, Balochistan to Karachi and the Sindh region. In contrast, SNGPL is responsible for gas transmission and distribution in the Punjab, Khyber Pakhtunkhwa (KPK) and Azad Jammu and Kashmir (AJK) regions of Pakistan. This study focuses on the main functions of SNGPL.

Sui Northern Gas Pipelines Limited (SNGPL) was founded in 1963 as private company and converted into a public sector company in January 1964. SNGPL is a leading public sector enterprise with significant

growth and high standing. The company holds ISO 14001:2004 and OHSAS 18001:2007 certifications. SNGPL's network extends from Sui to Multan, acquired from the Pakistan Industrial Development Corporation (PIDC), including 217 miles of 16 inch and 80 miles of 10-inch diameter pipelines. It also acquired the Dhulian Rawalpindi-Wah network from Attock Oil Company Limited, which includes 82 miles of 6-inch diameter pipelines. With over 50 years of experience, SNGPL specializes in the operation and maintenance of high-pressure gas transmission and distribution networks. The company has expanded its services to include Design, Engineering, Procurement and Construction (EPC) contracting, covering planning, designing and construction of pipelines both for itself and other organizations. SNGPL's transmission network spans over 8,900 kilometers, and its distribution network covers 122,325 kilometers, serving 4,458 main towns and surrounding villages through 16 regional offices. SNGPL caters to over 6.5 million consumers across various sectors, including commercial, domestic, general industry, fertilizer power, and cement.

## RESEARCH METHODOLOGY

### Measures and Procedures

This research employed both qualitative and quantitative techniques. The quantitative aspect involves data collection through survey-based questionnaires. Given the extensive consumer base of SNGPL, data were gathered from its customers. The survey questionnaire consisted of two sections. The first part consists of personal information and demographics. This section gathers data on respondents' gender, marital status, monthly income, age, educational level, and occupation. The second part of the questionnaire consists of questions related to SNGPL services. A Likert scale was used to collect responses, and the data were analyzed using multiple regression analysis. This analysis aimed to determine the importance of consumer expectations (voice of the customer, or WHATs) and to assess correlations between these expectations and technical solutions (HOWs). A Pareto chart was also used to develop the HOQ. A simple random sampling method was used for data collection. Questionnaires were distributed to SNGPL customers in the twin cities of Islamabad and Rawalpindi. Respondents were given eight days to complete and return the questionnaires. Follow ups were conducted to ensure the completion of the questionnaire. Out of 175 distributed questionnaires, 160 were returned. After excluding responses with missing data and outliers, 130 valid responses were used in the analysis.

### Implementation of QFD

#### *Demographic Results*

After collection of the questionnaires, we first analyzed the demographic data. Table 1 shows this data, revealing that 23 percent of respondents were female and 77 percent were male. Among the respondents, 46 percent were single and 54 percent were married.

**Table 1**

*Demographic Results*

| Demographics | Category | Percentage (%) |
|---|---|---|
| Gender | Male | 77 |
| | Female | 23 |
| Marital Status | Single | 46 |
| | Married | 54 |
| Age | Less than 20 | 3 |
| | 20-30 | 51 |
| | 31-40 | 15 |
| | 41-50 | 7 |
| | 51 or above | 24 |
| Educational Level | Matriculation | 0 |
| | Intermediate | 3.9 |
| | Bachelor | 42.2 |
| | Masters | 28 |
| | PhD/MS/MPhil | 25.1 |
| | None of the above | 0.8 |
| Occupation | Government sector | 18.3 |
| | Semi-government sector | 11.1 |
| | Self employed | 12.7 |
| | Private sector | 33.3 |
| | Student | 24.6 |

***Voice of the Customer***

To identify customers and the target markets, various methods can be employed to capture the needs of customers (Woodruff, 1997). It is crucial to listen to every customer to analyze their needs effectively, as the main objective of QFD is customer satisfaction (Mallon & Mulligan, 1993). In this study, customer feedback was gathered through a questionnaire distributed to a sample of people. Once the questionnaires were completed, the responses were analyzed using a scaling technique, with scores ranging from a scale of 0 to 100, to quantify qualitative responses. After determining the factors and their ratings, multiple regressions analysis was performed to assess the importance of customer expectations or WHATs, by grading them on a scale from 0 to 100. The goal was to rank these expectations by their level of importance. Table 2 shows the customer requirements along with their respective weights.

**Table 2**

*Requirement of Customers*

| No. | WHATs | Weighting |
|---|---|---|
| 01. | Media preference for receiving gas load shedding schedule information | 100 |
| 02. | Replacement of gas meter | 70 |
| 03. | Satisfaction with the quality of service | 80 |
| 04. | Satisfaction with the customer service of SNGPL | 50 |
| 05. | Timely receipt of monthly gas bills | 60 |

(continued)

| No. | WHATs | Weighting |
|---|---|---|
| 06. | Reliability of the gas meter | 80 |
| 07. | Availability of an alternative method to measure gas or further automation of existing meters | 80 |
| 08. | Mode of new gas meter installation | 76 |
| 09. | Time required for gas meter installation | 90 |
| 10. | Misconceptions about inflated bills following meter replacement | 50 |
| 11. | Complaints regarding gas leakages or low pressure | 60 |
| 12. | Satisfaction with SNGPL's response to meter requirements | 70 |
| 13. | Discontinuation notices for unpaid bills | 20 |
| 14. | Uninterrupted gas supply to homes | 70 |
| 15. | Real-time tracking system of SNGPL | 60 |
| 16. | Presence of new domestic gas suppliers competing with SNGPL | 80 |
| 17. | Damages experienced during crises | 50 |

### *Voice of the Technical Team*

In the "Voice of the Technical Team," each customer requirement was matched with the corresponding services provided by SNGPL (Anwar et al., 2010). Once customer expectations are defined, it is crucial to address each of their concerns (Pizam et al., 2016). These requirements are fulfilled by the technical team of the company (Sivasamy et al., 2016). The expertise and experience of the team are translated into HOWs to support the customers' WHATs. To gather this information, interviews were conducted with senior engineers and other employees at SNGPL, as detailed in Table 3.

**Table 3**

*List of Interviewees*

| Interviewee | Designation | Organization |
|---|---|---|
| Interviewee 1 | Computer Operator | SNGPL Regional office Islamabad |
| Interviewee 2 | Senior Engineer | SNGPL Sub-regional office Wah Cantt. |
| Interviewee 3 | Senior Engineer | SNGPL Regional office Rawalpindi |
| Interviewee 4 | Senior Engineer | SNGPL Regional office Rawalpindi |

The interviewees provided clear and valuable insights. All relevant points were thoroughly discussed, and the qualitative data was systematically analyzed. The customer requirements collected from the questionnaires was a major source for obtaining more specific data during the interviews. We prepared a list of questions and assigned unique codes to them. Key notes from the interviews were also coded using sentences or text segments, which were later organized into qualitative codes. The frequency of these codes was tracked to gather extensive information within a limited time frame. The qualitative codes and their frequencies are illustrated in Figure 3 and Figure 4. The recorded interviews captured the technical team's responses to customer requirements, as summarized in Table 4.

**Table 4**

*Voice of Technical Team*

| No. | Customer Requirement (WHATs) | Technical Requirement (HOWs) |
|---|---|---|
| 01 | Providing gas load shedding schedule information through internet, mobile, TV, newspapers | Dissemination of information via various media channels, including print and electronic media |
| 02 | Replacement of gas meters as needed | Implementing error prevention measures |
| 03 | Ensuring satisfaction with the quality of service | Emphasizing employee focus and training |
| 04 | Delivering efficient customer services | Operating Customer Service Center/Complaint Center |
| 05 | Timely delivery of monthly Gas bills | Managing bill distribution efficiently |
| 06 | Ensuring the reliability of gas meters | Ensuring meters are static and accurate |
| 07 | Timely installation time of gas meter | Adopting a "First Come, First Served" basis for processing consumer application based on maturity level |
| 08 | Addressing misconceptions about inflated bills following meter replacement | Adjusting services according to gas consumption levels |
| 09 | Ensuring uninterrupted gas supply | Clearly defining and adhering to company's mission and vision |
| 10 | Implementing real-time tracking system for new gas meter installations | Utilizing an ORACLE-based module known as CC&B (Customer care and billing) |
| 11 | Competing with new domestic gas suppliers in the market | Promoting good governance within the public sector organization |
| 12 | Exploring alternative methods to measure gas consumption besides traditional gas meters | Ensuring gas meter reliability; considering prepaic methods used in some European countries where gas is purchased as required in cylinders |
| 13 | Facilitating the installation of new gas meters through internet-based methods | Providing effective customer services |
| 14 | Responding effectively to complaints regarding gas leakages or low pressure | Prioritizing emergencies through the Emergency Department/Customer Services department, particularly for gas leakages. OGRA has predefined response times for gas leakage complaints, which SNGPL adheres. For low pressure complaints, the Metering/Operations/Customer Service/ Maintenance departments are involved. |
| 15 | Sending notices about meter discontinuation due to unpaid bills | Efficient customer service |
| 17 | Providing reliable services during crises | Conducting pressure profiling to address load management issues |

**Table 5**

*Part Deployment against Technical Specifications*

| No. | Technical Requirements (HOWs) | Characteristics/ Processes |
|---|---|---|
| 01 | Dissemination of information via various media channels, including print and electronic media | Information dissemination: Utilizing social media sites (Twitter, Facebook) and newspapers for communication |
| 02 | Implementation of error prevention measures | Error management: Addressing consumer damages and issues with faulty/sticky meters |
| 03 | Emphasis on employee training and focus | System access: Employing the CC&B ORACLE-based login for activity authorization by employees |
| 04 | Operation of Customer Service Centers/Complaint Centers | Service availability: Operating customer support 24/7 through phone and/or on-site visits |
| 05 | Effective management of bill distribution | Payment management: Handing payments on a monthly-basis |
| 06 | Ensuring meters are static and accurate | Meter accuracy: Using imported meters and recorded gauging methods to ensure accuracy |
| 07 | Processing consumer applications on a "First Come, First Served" basis based on the maturity level of the application | Application management: Implementing computerized applications for efficient processing |
| 08 | Adjusting services based on gas consumption levels | Billing accuracy: Ensuring that meters provide accurate readings and bills |
| 09 | Clearly defining and adhering to the company's mission and vision | Regulatory compliance: Adjusting services based on government priorities, demand & supply, and local arrangements, including LNG |
| 10 | Utilizing ORACLE based module known as CC&B – (Customer care and billing) | Application follow-ups: Tracking the status of customer applications |
| 11 | Promoting good governance among public sector organization | Organizational focus: maintaining a competitive and focused approach |
| 12 | Ensuring gas meter reliability, with alternative prepaid methods as used in some European countries where gas is purchased as needed in cylinders | Reliability: Ensuring reliability in gas consumption and customer satisfaction. |
| 13 | Providing effective customer services, including new gas meter installations through the internet | Online portal: Managing services through the SNGPL website portal |
| 14 | Prioritizing emergencies through the Emergency Department/Customer Services department, particularly for gas leakages. OGRA has predefined response time for gas leakage complaints, which SNGPL follows. For low pressure complaints, the Metering, Operations, Customer Service, and Maintenance departments are involved | Effective customer service: Providing comprehensive customer support |
| 15 | Managing effective customer services related to discontinuation of gas meters due to unpaid bills | Issue warnings regarding account status on bills |
| 16 | Conducting pressure profiling to address load management issues | Pressure management: Adjusting gas pressure based on demand and state conditions |

***Parts Deployment***

In the second phase of QFD, known as part development, we highlighted part characteristics in relation to the technical specifications of SNGPL. This phase involves conducting surveys to gather insights from SNGPL. All technical requirements were presented to senior executives of SNGPL, who provided detailed explanations of the processes and steps being taken to meet the specifications. Table 5 lists the key elements associated with the technical requirements. These elements were instrumental in the formation of the second stage of QFD.

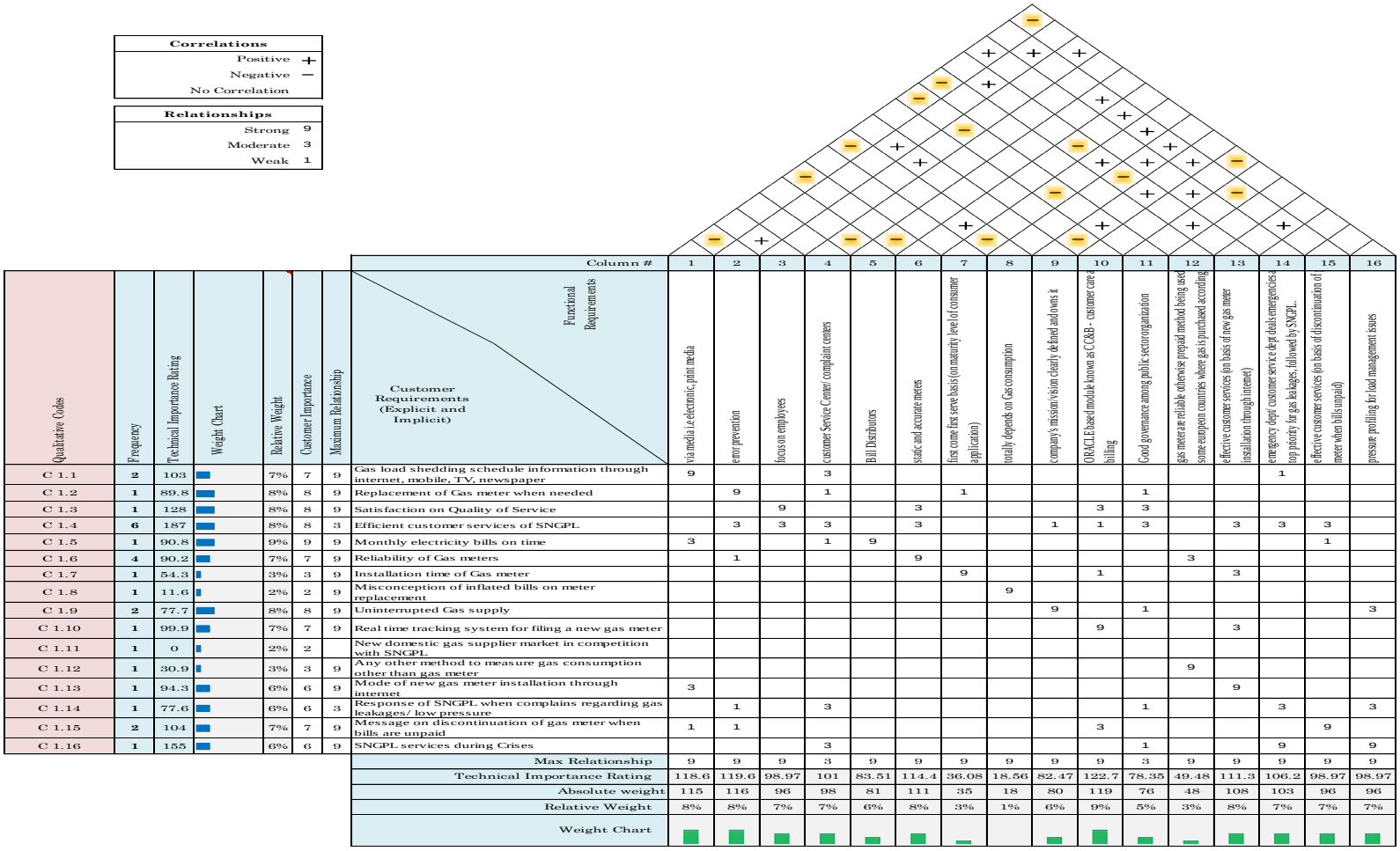
***Correlation Matrix Development***

In the QFD methodology, numerical values are assigned to illustrate the relationship between WHATs (i.e. customer needs) and HOWs (i.e. technical requirements). In this research, the scale used is as follows: 9 indicates a strong relationship, 3 indicates a medium relationship, 1 indicates a weak relationship, and a blank space denotes no relationship (Anwar et al., 2010). These numerical ratings are determined by several experts, and an average is calculated based on their consensus. The inter relationship between the HOWs shows how each technical requirement affects the others. In order to assess these relationships, various symbols are employed to represent different levels of importance: + denotes a positive correlation, - indicates a negative correlation, and a blank space shows no correlation. These relationships were established by SNGPL experts.

HOQ model shows the relationship between WHATs and HOWs. Figure 1 shows the correlation between customer requirements and technical specifications, while Figure 2 illustrates the relationship between technical specifications and part deployment. These HOQ diagrams also include technical importance ratings, absolute and relative weights, which are further detailed in weight charts. Absolute weights calculated in QFD specify areas that require a company's focus. A high absolute weight indicates a critical point that demands significant attention to maintain market position. Both absolute and relative weights are shown in Figure 1 and Figure 2. Additionally, the researcher has defined qualitative codes and their frequencies for each descriptor in the HOQ diagram to record the occurrence of each descriptor.

**Figure 1**

*HOQ Model Showing Correlation between WHATs and HOWs*



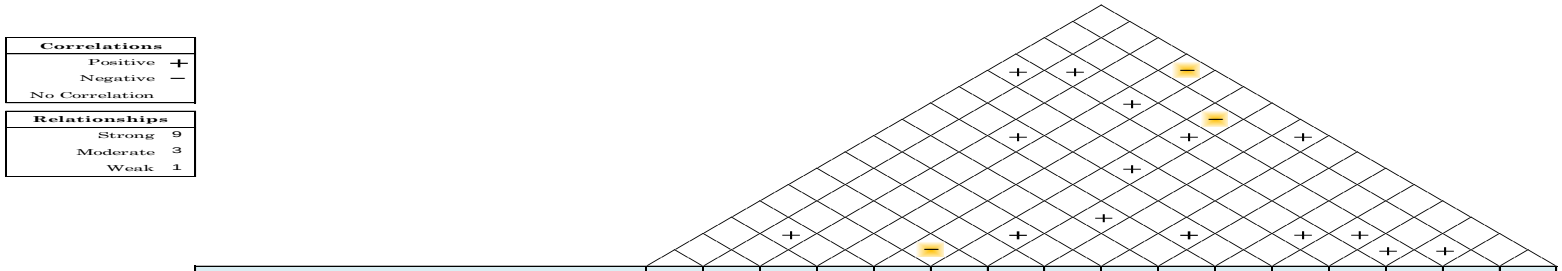
| Correlations | |
|---|---|
| Positive | + |
| Negative | − |
| No Correlation | |

| Relationships | |
|---|---|
| Strong | 9 |
| Moderate | 3 |
| Weak | 1 |

| Qualitative Codes | Frequency | Technical Importance Rating | Weight Chart | Relative Weight | Customer Importance | Maximum Relationship | Customer Requirements (Explicit and Implicit) / Functional Requirements | Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | via media i.e electronic, print media | error prevention | focus on employees | customer Service Center/ complaint centers | Bill Distributors | static and accurate meters | first come first serve basis (on maturity level of consumer application) | totally depends on Gas consumption | company's mission/vision clearly defined and owns it | ORACLE based module known as C&B - customer care & billing | Good governance among public sector organization | gas meters are reliable otherwise prepaid method being used some european countries where gas is purchased according | effective customer services (on basis of new gas meter installation through internet) | emergency dept/ customer service dept deals emergencies in top priority for gas leakages, followed by SNGPL. | effective customer services (on basis of discontinuation of meter when bills unpaid) | pressure profiling for load management issues |
| C 1.1 | 2 | 103 | | 7% | 7 | 9 | Gas load shedding schedule information through internet, mobile, TV, newspaper | | 9 | | | 3 | | | | | | | | | | 1 | | |
| C 1.2 | 1 | 89.8 | | 8% | 8 | 9 | Replacement of Gas meter when needed | | | 9 | | 1 | | | 1 | | | | 1 | | | | | |
| C 1.3 | 1 | 128 | | 8% | 8 | 9 | Satisfaction on Quality of Service | | | | 9 | | | 3 | | | | 3 | 3 | | | | | |
| C 1.4 | 6 | 187 | | 8% | 8 | 3 | Efficient customer services of SNGPL | | | 3 | 3 | 3 | | 3 | | | 1 | 1 | 3 | | 3 | 3 | 3 | |
| C 1.5 | 1 | 90.8 | | 9% | 9 | 9 | Monthly electricity bills on time | | 3 | | | 1 | 9 | | | | | | | | | | 1 | |
| C 1.6 | 4 | 90.2 | | 7% | 7 | 9 | Reliability of Gas meters | | | 1 | | | | 9 | | | | | | 3 | | | | |
| C 1.7 | 1 | 54.3 | | 3% | 3 | 9 | Installation time of Gas meter | | | | | | | | 9 | | | 1 | | | 3 | | | |
| C 1.8 | 1 | 11.6 | | 2% | 2 | 9 | Misconception of inflated bills on meter replacement | | | | | | | | | 9 | | | | | | | | |
| C 1.9 | 2 | 77.7 | | 8% | 8 | 9 | Uninterrupted Gas supply | | | | | | | | | | 9 | | 1 | | | | | 3 |
| C 1.10 | 1 | 99.9 | | 7% | 7 | 9 | Real time tracking system for filing a new gas meter | | | | | | | | | | | 9 | | | 3 | | | |
| C 1.11 | 1 | 0 | | 2% | 2 | | New domestic gas supplier market in competition with SNGPL | | | | | | | | | | | | | | | | | |
| C 1.12 | 1 | 30.9 | | 3% | 3 | 9 | Any other method to measure gas consumption other than gas meter | | | | | | | | | | | | | 9 | | | | |
| C 1.13 | 1 | 94.3 | | 6% | 6 | 9 | Mode of new gas meter installation through internet | | 3 | | | | | | | | | | | | 9 | | | |
| C 1.14 | 1 | 77.6 | | 6% | 6 | 3 | Response of SNGPL when complains regarding gas leakages/ low pressure | | | 1 | | 3 | | | | | | | 1 | | | 3 | | 3 |
| C 1.15 | 2 | 104 | | 7% | 7 | 9 | Message on discontinuation of gas meter when bills are unpaid | | 1 | 1 | | | | | | | | 3 | | | | | 9 | |
| C 1.16 | 1 | 155 | | 6% | 6 | 9 | SNGPL services during Crises | | | | | 3 | | | | | | | 1 | | | 9 | | 9 |
| | | | | | | | Max Relationship | | 9 | 9 | 9 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 9 | 9 | 9 | 9 | 9 |
| | | | | | | | Technical Importance Rating | | 118.6 | 119.6 | 98.97 | 101 | 83.51 | 114.4 | 36.08 | 18.56 | 82.47 | 122.7 | 78.35 | 49.48 | 111.3 | 106.2 | 98.97 | 98.97 |
| | | | | | | | Absolute weight | | 115 | 116 | 96 | 98 | 81 | 111 | 35 | 18 | 80 | 119 | 76 | 48 | 108 | 103 | 96 | 96 |
| | | | | | | | Relative Weight | | 8% | 8% | 7% | 7% | 6% | 8% | 3% | 1% | 6% | 9% | 5% | 3% | 8% | 7% | 7% | 7% |
| | | | | | | | Weight Chart | | | | | | | | | | | | | | | | | |

**Figure 2**

*QFD Model Showing Correlation between Technical Specifications and Parts Characteristics*




| Qualitative Codes | Frequency | Weight Chart | Relative Weight | Customer Importance | WHATs \ HOWs | 1 social sites (twitter, Facebook,) newspaper | 2 consumer damages, faulty/sticky meters | 3 CC&B oracle based login for activity authorization (for employees) | 4 24/7 operated through phone or visits | 5 monthly basis payments | 6 imported meters, gauging methods are recorded always | 7 computerized applications | 8 accurate meters with accurate bills | 9 depends on government priorities and demand & supply (there are local arrangements as well as LNG) | 10 application followups | 11 competitive and focused organization | 12 reliable in terms of gas consumption and customer satisfaction | 13 SNGPL website portal defined | 14 effective customer services | 15 warning given by mentioning on bills | 16 Gas pressure increase/decrease depending on the state |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C 2.1 | 2 | ▮▮▮▮▮ | 6% | 8 | Via media i.e electronic, print media | 9 | | | 1 | | | | | | | | | | | | |
| C 2.2 | 2 | ▮▮▮▮▮ | 7% | 9 | Error prevention | | 9 | | 3 | | 9 | | | | 3 | | | | 3 | | |
| C 2.3 | 1 | ▮▮▮ | 5% | 7 | Focus on employees | | | 9 | | | | | | | | 3 | | | | | |
| C 2.4 | 6 | ▮▮▮▮▮ | 7% | 9 | Customer Service Center/ complaint centers | | | | 9 | | | | | | | 3 | 3 | 3 | 9 | | |
| C 2.5 | 1 | ▮▮▮ | 5% | 6 | Bill distributors | | | | | 9 | | | | | | | | 9 | | | |
| C 2.6 | 5 | ▮▮▮▮▮ | 7% | 9 | Static and accurate meters | | | | | | 9 | 1 | 9 | | 1 | | | | | | |
| C 2.7 | 2 | ▮▮▮▮▮ | 7% | 9 | First come first serve basis (on maturity level of consumer application) | | | | | | | 9 | | | 9 | | | | 3 | | |
| C 2.8 | 1 | ▮▮▮▮▮ | 7% | 9 | Totally depends on Gas consumption | | | | | | 1 | | 9 | | | 3 | | | | | |
| C 2.9 | 1 | ▮▮▮▮▮ | 6% | 8 | Company's mission/vision clearly defined and owns it | | | | | | | | | 9 | | 9 | | | | | |
| C 2.10 | 2 | ▮▮▮ | 5% | 7 | ORACLE based module known as CC&B - customer care and billing | | | 9 | 1 | | | | | | 9 | | | 1 | | | |
| C 2.11 | 2 | ▮▮▮▮▮ | 7% | 9 | Good governance among public sector organization | | | 1 | | | | | | | | 9 | | | 3 | | |
| C 2.12 | 1 | ▮▮▮▮▮ | 7% | 9 | Gas meter are reliable otherwise prepaid method being used in some europeon countries where gas is purchased according to requirements in cylinders etc | | | | | | 9 | | 9 | | | | 9 | | | | |
| C 2.13 | 3 | ▮▮▮▮▮ | 7% | 9 | effective customer services (on basis of new gas meter installation through internet) | | | | | | | | | | | | | 9 | 3 | | |
| C 2.14 | 2 | ▮▮▮▮▮ | 6% | 8 | emergency dept/ customer service dept deals emergencies at top priority for gas leakages, followed by SNGPL. For low pressure complaints, metering/operation/CS/maintenance dept plays its role | | 1 | | 1 | | | | | | | | | | 9 | | 1 |
| C 2.15 | 1 | ▮▮▮▮▮ | 6% | 8 | effecient customer services (on basis of discontinuation of gas meter when bills unpaid) | | | | | | | | | | | | | | | 9 | |
| C 2.16 | 1 | ▮▮▮▮▮ | 6% | 8 | pressure profiling for load management issues | | | | | | | | | | | | | | 3 | | 9 |
| | | | | | Technical Importance Rating | 54.55 | 67.42 | 102.3 | 99.24 | 40.91 | 190.9 | 68.18 | 184.1 | 54.55 | 136.4 | 172.7 | 81.82 | 128 | 215.9 | 54.55 | 60.61 |
| | | | | | Absolute weight | 72 | 89 | 135 | 131 | 54 | 252 | 90 | 243 | 72 | 180 | 228 | 108 | 169 | 285 | 72 | 80 |
| | | | | | Relative Weight | 3% | 4% | 6% | 6% | 2% | 11% | 4% | 11% | 3% | 8% | 10% | 5% | 7% | 13% | 3% | 4% |
| | | | | | Weight Chart | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ | ▮ |

***Pareto Chart***

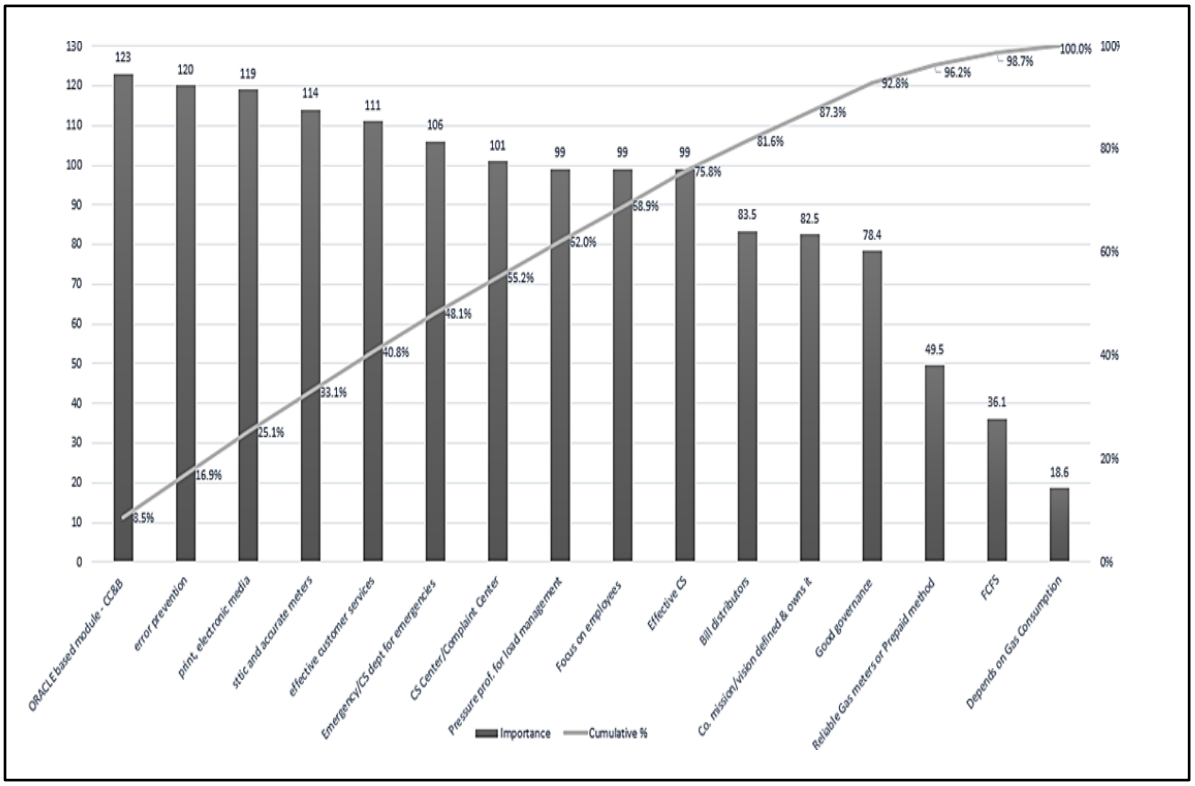
The Pareto chart is used to identify and emphasize the most important factors among a broader set. It highlights which factors should be prioritized based on the stages outlined in the House of Quality.

*Pareto Chart for HOQ I*

Figure 3 provides a graphical representation of technical specifications in HOQ I, identifying factors that are crucial for company growth and service efficiency. For instance, SNGPL has recently implemented the ORACLE-based module, CC&B, which covers everything from new gas applications to billing history. This module addresses many customer requirements and adds significant value to the organization.

**Figure 3**

*Pareto Chart for HOQ I*




The second important factor is the recovery and error prevention of gas meters. Timely handling of these issues is essential for maintaining accuracy. Third, proper recording of meter gauging is also crucial for ensuring reliable and accurate meters. Faulty or sticky meters should either be replaced or properly calibrated by SNGPL to ensure accuracy. Additional factors include: Gas load shedding schedules: These need to be communicated effectively. Emergency Department/Customer Services: The emergency department and customer services should be more localized to handle emergencies, such as gas leakages, as a top priority. OGRA compliance: The Oil and Gas Regulatory Authority (OGRA) has set predefined response times for gas leakage complaints, which SNGPL must follow. Low pressure complaints: Addressed by the Metering/Operations/CS/Maintenance department. These

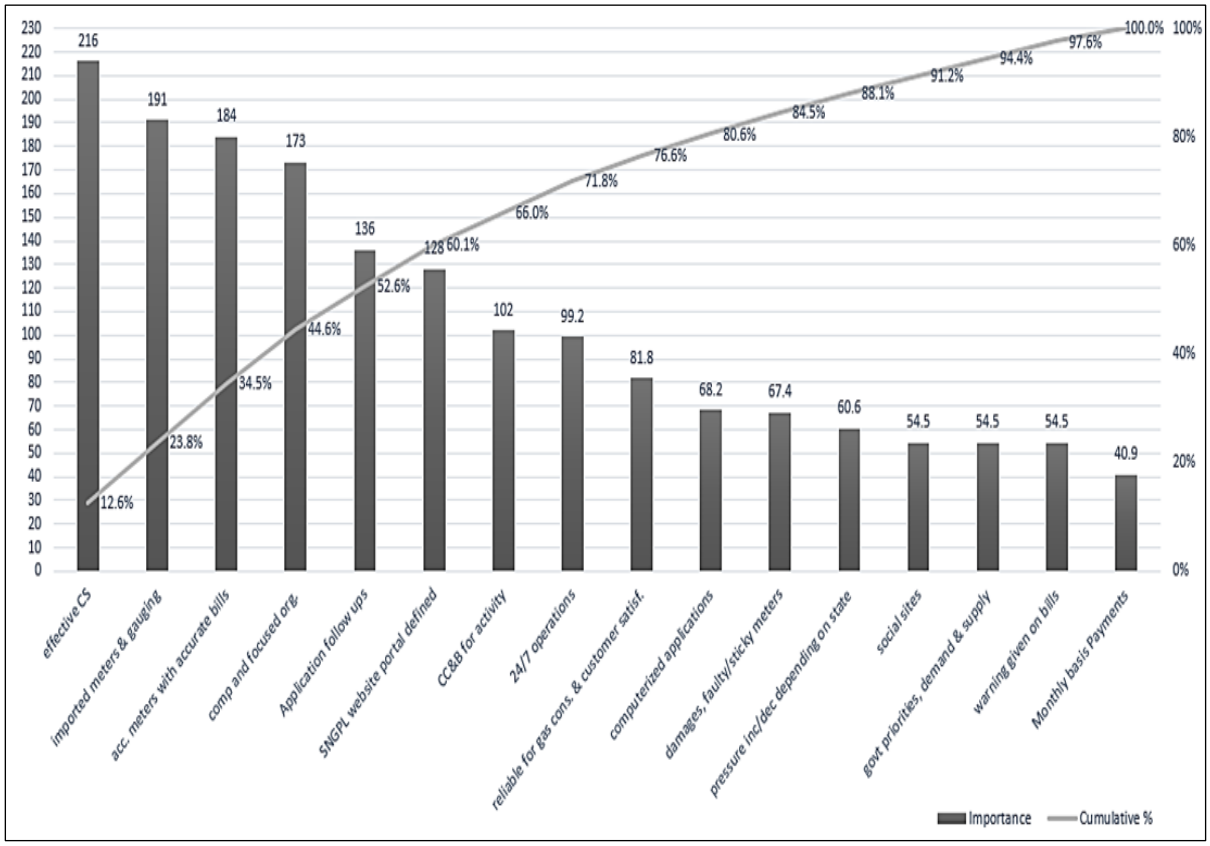
departments play a vital role in addressing customer issues. By paying closer attention to these areas, SNGPL can improve customer satisfaction.

***Pareto Chart for HOQ II***

Figure 4 illustrates the graphical representation of part characteristics in HOQ II. This chart highlights the factors that should be prioritized to improve services and enhance customer satisfaction. Key points include: Website and mobile app: The SNGPL website portals should be well defined for tracking complaints regarding low pressure or gas leakages and for processing new applications. Additionally, the application follow ups should be computerized, and a mobile app for Sui Gas should be developed to streamline these processes.

**Figure 4**

*Pareto Chart Showing Second Stage HOQ Factors*




These Pareto charts emphasize that organizations can achieve greater optimization by focusing on the vital few rather than trivial many. The analysis revealed that focusing on these specific points can address approximately seventy percent of the issues.

## DISCUSSIONS

### Error Prevention

SNGPL operates a 24 x 7 call center or "1199" designed to assist consumers. In major cities and areas of Punjab, KPK, and some parts of AJK, SNGPL has offices where individuals can visit to address their complaints. At these offices, priority is given to addressing issues related to meter replacements as swiftly as possible, given that the SNGPL billing system depends on accurate meter reading from consumer premises. To enhance service efficiency, SNGPL should implement a policy where a qualified technician is dispatched within three to four hours for meter replacement or repairs. If SNGPL fails to take timely action, they should be required to provide compensation within ten working days. Should they miss this deadline, the compensation amount should be doubled (National Association of Citizens Advice Bureaux, n. d.). This approach could significantly improve the handling of meter replacement complaints.

### Improving Employee Efficiency

Customer satisfaction is crucial for organizational success, and this satisfaction is often a reflection of employee satisfaction. Employees are more likely to perform efficiently when they are valued and motivated. Offering incentives or rewards based on performance can significantly enhance employee efficiency. Incentive plans generally fall into two main categories: individual incentive plan, and group incentive plan. Individual incentive plan includes the following types: the Halsey Plan, the Rowan Plan, the Emerson Plan and the Bandeaux Plan. Each of these plans provides rewards to employees based on their individual performance and meeting specific conditions. On the other hand, group incentive plan provides bonuses to teams or groups of workers in addition to their individual bonuses. These plans include the Priestman plan, the Profit Sharing Method and the Scanlon Plan, each offering different approaches to distributing bonuses (SHMA, 2013).

SNGPL currently provides various incentives to its employees to enhance motivation. These incentives are categorized based on employee levels. For lower-level staff, SNGPL offers benefits such as timely monthly income, overtime pay, annual increments, travel allowances (TA/DA), promotions, adherence to labor rules, free medical facilities for employees and their families, special increments for extraordinary performance, educational/ annual fee benefits for employees' children, free gas facilities and employee insurance. For senior staff, SNGPL provides timely monthly income, overtime pay, adherence to labor rules, educational/ annual fee benefits for employees' children and free gas facilities. While SNGPL already offers a range of incentives, it could further enhance employee motivation by adopting additional incentive plans for its environment, such as the Halsey Plan and various group incentive plans.

### Effective Customer Services

In today's technology-driven world; people prefer instant services accessible via smartphones or desktops, reducing the need to queue in long lines. SNGPL has adapted to this trend by allowing customers to apply for new gas meter connections and track their application status through its website. However, submitting the required documents still necessitates a visit to a local SNGPL office. Once the application is processed and reaches its turn based on merit, the sales department conducts a survey at the consumer's premises to verify legal requirements. Following this, the consumer receives a demand notice and once the service line is laid and the meter is installed, the entire process can be tracked

through the SNGPL website. For customers with unpaid gas bills, a "Disconnection Sent" message is printed on their bill to indicate overdue payments. While the requirement for hand submission of documents has decreased, as customers prefer completing procedures online, there is a need for a comprehensive mobile application for Sui Gas. This app should include all customer service features, enabling users to manage their accounts and services more efficiently.

**Reliable, Static and Accurate Meters**

Gas meters are essential for accurately measuring gas consumption. During their monthly readings, SNGPL's personnel use digital display devices to record the meter's value. If a meter gets faulty, it is typically identified by the vigilance team or through consumer complaints. Meters generally function accurately unless mishandled. SNGPL replaces meters at regular intervals as specified in its standard operating procedures (SOPs). During a survey, SNGPL experts were asked if there are alternatives to traditional gas meters. They noted that European countries use prepaid methods for purchasing gas, which could be an option for SNGPL. Additionally, implementing Advanced Metering Interface (AMI) systems could be beneficial. AMI systems can reduce gas losses, detect leaks and provide accurate, static readings (Webb, 2018).

**Good Governance in Public Sector Organizations**

SNGPL is performing effectively as a public sector organization and continually strives to improve its services to meet consumer expectations. However, effective governance requires robust government policies to bridge the gap between demand and supply. To address areas where network expansion is not feasible, alternative energy conservation methods and renewable energy solutions should be explored. These initiatives would help increase consumer coverage and enhance overall satisfaction.

**Media Outreach: Print and Electronic**

Marketing is a crucial tool for promoting products and services to customers. It employs various channels, such as social media, emails, letters, and websites. In the realm of digital marketing, devices like smartphones, computers and tablets are used to reach potential customers. Gas load-shedding occurs when there is a discrepancy between demand and supply. When this happens, SNGPL management assesses the situation and informs the Ministry of Energy (Petroleum Division). Upon receiving government approval, SNGPL communicates details about gas load shedding—including causes, reasons, and schedules—to consumers through print and electronic media.

**Customer Service Center/ Complaint Center/ Emergency Department**

A Customer Care Service Center is essential for addressing customer needs and queries about products or services. Companies should provide robust customer service centers that operate 24/7 via telephone and in-person visits. SNGPL has established Customer Service and Complaint Centers at major locations to assist its customers. With over six million consumers spread across 16 regions in Punjab and Khyber Pakhtunkhwa, these centers are crucial for effective customer support. For issues like gas leaks or low-pressure, SNGPL has established an emergency response department that prioritizes handling such complaints to prevent any hazardous situations. The Metering, Operations, Customer Service, and Maintenance departments address complaints related to low gas pressure.

**Bill Distributors**

SNGPL employs third party services for bill distribution. Bills are dispatched monthly to consumers, ensuring a reliable system, especially in areas where most consumers may not have internet access or smartphones. If a consumer does not receive their bill, they can lodge a complaint at a nearby SNGPL office. Additionally, bills can be accessed through the SNGPL website, where consumers can also perform their own calculations.

**First Come, First Serve Basis**

According to SNGPL expert, the standard waiting period for gas meter installation is a minimum of 90 days, as noted on the application receipt. Due to high demand for new gas connections, SNGPL follows a first come, first serve approach. Applying for gas meter installation online is the most straightforward and convenient method. The website portal should facilitate the process by providing an installation date, after which an installation team will be dispatched to the customer's house.

**Oracle Based Module CC&B – Customer Care and Billing**

Currently, there is no feedback tracking system available for customers who request for a new meter. In response to this issue, SNGPL has implemented an ORACLE-based module known as CC&B (Customer care and billing). This module provides a comprehensive solution, covering all aspects from new gas application submission to billing history. The implementation of CC&B is a significant improvement for SNGPL, offering customers a robust platform to manage their requirements effectively.

**Pressure Profiling for Load Management Issues**

During peak load periods, SNGPL teams work around the clock to support their customers. To address load management issues, SNGPL employs pressure profiling, which involves adjusting gas pressure levels by increasing or decreasing them as needed. The network is modified to connect low-pressure facility lines with high pressure lines, ensuring more effective management of gas supply.

**Competitive and Focused Organization**

SNGPL has established a strong market presence by providing efficient services to its customers, including providing uninterrupted gas supply and addressing gas-related complaints. The organization has a clear vision and mission and actively works towards achieving them. SNGPL operates with local resources, including wells, and LNG facilities, and maintains good governance within the public sector. Despite competition in the domestic market, SNGPL continues to thrive by focusing on its core values and service excellence.

## CONCLUSION, IMPLICATIONS, AND FUTURE RESEARCH DIRECTIONS

This research examines the application of quality function deployment (QFD) in the gas sector, a key player in the public energy sector. The study was conducted in two stages: the House of Quality and the part development study focusing on all parameters that impact the system. The results revealed that the most critical quality indicators are effective customer service, a competitive and focused organization,

the use of imported meters and accurate gauging methods, reliable meters with precise billing, and emergency departments that prioritize urgent issues.

The study identifies 16 key customer demands essential for enhancing performance. These demands include: gas load-shedding schedule information accessible through internet, mobile, TV and newspapers; timely replacement of gas meters; satisfaction with the quality of service; efficient customer services from SNGPL, on-time delivery of monthly electricity bills; reliability of gas meters; installation time of gas meters; addressing misconceptions about inflated bills following meter replacement; uninterrupted gas supply, real-time tracking system for new gas meter applications; competition from new domestic gas suppliers; exploration of alternative methods for measuring gas consumption; online application for new gas meter installation; SNGPL's response to complaints regarding gas leaks or low pressure; clear messaging on gas meter disconnection due to unpaid bills; SNGPL services during crises and a proper mechanism for applying for new gas meters. The inductive framework proposed in this study is both interlinked and practical, evaluated using standard QFD techniques. It is applicable to similar situations in other sectors. The findings provide guidelines for enhancing SNGPL's performance and stimulate further empirical research related to quality function deployment (QFD) in utility sectors of energy. Future research could extend this approach to multiple utility sectors and wider geographic areas, offering a more comprehensive analysis of customer needs through QFD.

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