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## Customer satisfaction on electricity service quality in Hanoi, Vietnam

**ABSTRACT:** Assessing customer satisfaction with the quality of electricity service provides important solutions to improve service quality, especially for a competitive electricity market. In Vietnam, the competitive retail electricity market is at the beginning stage, which requires the improvement of its service quality and customer satisfaction for the competitiveness advantage. The study presents the construction of a set of indicators to evaluate customer satisfaction in the electricity sector in Hanoi city, Vietnam, by four customer groups, including administration, resident, industry, and commerce. The novel research method of quantifying and evaluating electricity customer

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satisfaction is applied by combining the SERVPERF model to build a set of survey questions, descriptive statistics, and linear regression methods to analyze the results, and the Bootstrap to determine the weights of indicators. The study results showed that there was a clear difference in the assessment of customer satisfaction according to five criteria of service quality and four customer groups. The administration customer group had the highest satisfaction level (4.47/5.00 points), followed by the commerce group (4.41/5.00 points); the two groups of residents and industry had the same assessment level of 4.39/5.00 points. The overall score of customer satisfaction in Hanoi city was 4.41/5.00 points. Besides, the weights of the indicators also had a clear difference. The business image plays the most important role, contributing 21.39% to the customer satisfaction score, followed by customer service and communication (20.58 and 20.39%). Information on safety and power price, and power supply reliability contribute to the small shares of the overall customer satisfaction (19.34 and 18.30%). The study suggests that the Hanoi Electricity Company should focus on the most important indicators, and the least satisfied indicators, e.g., business image and information on safety and power price.

**KEYWORDS:** customer satisfaction, electricity service quality, competitive electricity market, SERVPERF, Bootstrap

## 1. Introduction

### 1.1. Context and rationale

The energy sector is the backbone of the socio-economy, providing the input for daily living and economic activities. However, it is the most significant contributor to the global greenhouse gas (GHG) emissions. The GHG emissions from the energy sector were up to 34.98 GtCO<sub>2</sub>eq in 2022 (IEA 2023), being equivalent to 66% of the global GHG emissions (Crippa 2024). The production and consumption of electricity alone contribute to 38% of the GHG emissions of the energy sector (IEA 2024), making it a hotspot in climate change mitigation and adaptation. The sustainable development of the energy and electricity sector, consequently, is crucial for every country and region, and should cover both the production and the demand side of electricity.

The traditional electricity market, which was vertically integrated and centrally regulated by one company, is gradually being replaced by the competitive electricity market. In Vietnam, the electricity sector has been restructured, with the completion of the competitive generation market in 2018. The competitive wholesale electricity market has been piloted from 2016 to 2018, and is now being implemented. By 2023, the competitive retail electricity market will be deployed.

In that context, customer satisfaction becomes crucial for the success of electricity companies in Vietnam. The study aims to assess customer satisfaction with electricity service quality in Hanoi, the capital of Vietnam. By identifying the link between customer satisfaction and service quality of a large electricity service provider, with various groups of customers, the

study will provide strategic suggestions for improving the electricity service quality, meeting the demand of customers, and well preparing for the competitive retail electricity market in the near future.

## 1.2. Literature review

The importance of customer satisfaction to service providers has been examined and verified in several sectors globally, through the positive links between customer satisfaction and profit of the companies in Sweden (Anderson et al. 1994), or between service quality, customer satisfaction and their loyalty in five Asian countries of China, Hong Kong, Japan, South Korea and Singapore (Gong and Yi 2018). In Vietnam, Nguyen et al. (2021) found that there are links among doctor satisfaction, customer orientation, customer satisfaction, and their loyalty in the health sector. In retail, Dam and Dam (2021) have observed the link between service quality, brand image, customer satisfaction, and customer loyalty, and identified that customer satisfaction positively impacts customer loyalty. Similarly, improvement in service quality enhances customer satisfaction and their loyalty.

In the electricity sector, several studies have been conducted to evaluate the service quality and customer satisfaction (as presented in Table 1). Most of these studies applied the SERVQUAL (Service quality) model and its variant SERVPERF (Service performance) for the evaluation. Nearly half of the studies applied SERVQUAL or combined it with modelling tools or statistical methods for analyzing the data and results (Duong and Anh 2021; Jawneh and Manneh 2020; Jou et al. 2022; Libo-on 2021; Olayinka et al. 2018; Ong et al. 2023). The majority of studies established the links between customer satisfaction and factors (or areas) of service quality; and only four studies (Carvalho 2017; Drosos et al. 2020; Mutua et al. 2012; Sikdar and Mitra 2020) obtained an overall customer (or consumer) satisfaction index (or score). In order to quantify the overall customer satisfaction index, it is necessary to obtain the weights of contribution of each factor, or identify the importance of each factor to the overall index. Determining these weighting contributions will be the basis for developing specific solutions to improve each factor separately and the overall satisfaction index.

Besides, all these studies randomly selected customers of electricity services within a geographical boundary (province(s) or a nation), who were then classified by their gender, age, or income. These criteria for classifying the sample are totally suitable for the statistical analysis purpose, with the focus on the customers (who pay for the electricity). However, it does not take into account the point of view of the electricity demand (point of view of the electricity consumers). In the electricity sector, the electricity customers are frequently categorized by the electricity consumption purposes, including administration, residential, industrial, and commercial. These groups of customers have their demand characteristics, from the amount of electricity consumption (tens of kWh per day for residents up to millions of kWh per day for industries), the electricity load curve by day or by year (daily peak hours of resident customers

TABLE 1. Literatures on customer satisfaction and service quality

TABELA 1. Literatura dotycząca satysfakcji klientów i jakości usług

Study	Aim of the study	Method	Geographical boundary	Type of customer	Indicator	Index
1	2	3	4	5	6	7
Carvalho 2017	Analyze the driver of household satisfaction with the quality of electricity service in 27 countries	Random Effects Logit models	Former Soviet Union countries	Households	Several indicators of cooking, heating, savings, life satisfaction, age, gender, power sector reform, communist party membership and relative income	Satisfaction with electricity supply
Drosos et al. 2020	Evaluate customer satisfaction in energy market in Greece	Multicriteria satisfaction analysis (MUSA)	Greece	Residential customers	Four criteria of services, staff, customer services and payments	Overall customer satisfaction score
Duong and Anh 2021	Evaluate service quality in renewable energy industry in Vietnam	SERVQUAL model to identify influencing factors, Performance Importance Analysis (IPA) to design and analyze questionnaires	Vietnam	Randomly selected customers in six northern provinces of Vietnam	Five key factors of reliability, assurance, responsiveness, tangible and empathy	Not available
Jawneh and Manneh 2020	Investigate the impacts of service quality on customer satisfaction in electricity companies in Gambia	Non-probability convenience sampling, SERVQUAL model, Descriptive statistics, correlation and regression analysis	Gambia	Domestic consumers	Seven factors of Tangible, Reliability, Responsiveness, Assurance, and Empathy, Stability and Security	Not available
Jou et al. 2022	Assess the service quality and customer satisfaction on payment system at electricity companies	SERVQUAL model and Structural Equation Modelling	Philippines	Residents in several municipalities	Seven factors of Tangibility, Responsiveness, Reliability, Assurance, Empathy, Covid-19 protocol, and only payment security	Not available

1	2	3	4	5	6	7
Libo-on 2021	Investigate customer satisfaction on the service provided by an electricity company in the Philippines	SERVPERF model	Philippines	Randomly selected employees and customers in 14 municipalities and one city	Five areas of reliability, assurance, tangibility, empathy, and responsiveness	Not available
Mutua et al. 2012	Estimate the level of satisfaction of Kenya consumers of biomass, petroleum, electricity, and renewable energy	European Customer Satisfaction Index model	Kenya	energy producers and consumers (enterprises, households, suppliers, producers, and distributors)	Service provider image, consumer loyalty, consumer expectations, consumer complaints, perceived value, perceived quality,	Overall customer satisfaction index
Navarro and Bacatan 2023	Establish the link between service quality and customer satisfaction in the Philippines.	MUSA with statistical tools such as Mean, Pearson, Product-Moment Correlation Coefficient and Multiple Linear Regression Analysis	Philippines	Random sampling of customers in 16 municipalities and two cities of two provinces	Five factors of assurance, empathy, reliability, responsiveness, tangibility	Not available
Olayinka et al. 2018	Examine the link between service quality and customer satisfaction of electricity service in Nigeria	SERVQUAL, with arithmetic mean, standard deviation, partial least squares structural equation model	Nigeria	Customers in a state	Five factors of assurance, empathy, reliability, responsiveness, tangibility	Not available
Peter and Batonda 2022	Assess the influence of service quality on Tanzanian customer satisfaction in energy sector	Pearson correlation and regression analysis	Tanzania	Customers in a district	Five factors of reliability, assurance, tangibility, empathy, and responsiveness	Not available
Santos Neto et al. 2022	Assess customer satisfaction in electric power	Structural equation modelling, with partial least squares	Brazil	Residential electricity consumers	American Customer Satisfaction Index (ACSI) and the ANEEL Customer Satisfaction Index (IASC)	Not available

1	2	3	4	5	6	7
Sharma 2010	Measure customer perceived service quality for electricity supply in India	Multiple regression analysis	India	Residential customers in a region	Electricity supply quality, responsiveness, convenience, reliability, assurance, pricing, and empathy	Not available
Sikdar and Mitra 2020	Measure the consumer satisfaction of electricity users in India	Fuzzy logic-based consumer satisfaction index (CSI)	India	Consumers in a city	Quality of services, supply restoration time, behavior of the Meter Inspectors and the pricing policy, billing system, bill payment systems and corporate imagery, and consumer relationship	Consumer satisfaction index
Thi and Thi 2020	Investigate factors that affect customer satisfaction with service quality of electricity in Vietnam	Exploratory factor analysis and multiple linear regression method	Vietnam	Consumers in a province	Five factors of power supply, information to customers, electricity bill, customer service, and brand image	Not available
Ong et al. 2023	Determine factor affecting customer satisfaction of national electric power company in the Philippines	SERVQUAL and expectation-confirmation theory approach	Philippines	Consumers of a provincial electricity company	Tangibility, Empathy and Responsiveness, assurance, and empathy	Not available

are from 5.00 to 8.00 and 18.00 to 22.00, while those of industry customers are from 6.00 to 14.00) to the price of electricity (lower price for industry, low voltage, non-peak hours, and higher price for resident, high voltage and during peak hours). Therefore, they have different requirements for electricity service quality, and their satisfaction patterns with the service quality are diverse. Grouping the electricity customers by their consumption purposes will provide detailed information of factors affecting each group of customers' satisfaction for improving service quality according to their exact needs.

### 1.3. Contribution and Structure of the paper

This study integrates a well-developed model for service quality assessment, e.g., the SERVPERF model, with several statistical analysis tools, e.g., descriptive statistics and linear regression methods, and the Bootstrap method to quantify and evaluate the customer satisfaction of electricity service in Hanoi, Vietnam. The study not only responds to the need of preparing for the competitive retail electricity market in Vietnam, but also fills in the academic gap by assessing customer satisfaction across groups of electricity users by their consumption purposes and suggesting an innovative method to quantify the contribution of various factors to the overall customer satisfaction index.

The paper is divided into four main parts. Following the Introduction, the section on Data and methods will describe the framework of the study, survey, model, and statistical analysis tools used in the study. The Results and discussion section presents the quantified customer satisfaction by groups of electricity users in Hanoi city, and a discussion on the obtained results. Finally, the paper ends with the Conclusion section, and some suggestions for future research.

## 2. Data and methods

### 2.1. Logical framework of the study

The framework for conducting the study integrates the SERVPERF model for establishing the link between customer satisfaction and service quality, and statistical analysis tools, e.g., Multiple Linear Regression model for quantifying and assessing customer satisfaction, and Bootstrap for determining the weighting contributions of each factor to the overall customer satisfaction. Figure 1 illustrates the step-wise logical framework of the study, specifically:

Step 1. Survey and sampling. This step involves the application of the SERVPERF model to create a list of indicators for assessing the electricity service quality. From the list of indicators,

a questionnaire, which is suitable for the sample and context of electricity consumption in Hanoi, Vietnam, is formed for conducting the survey.

Step 2. Statistical analysis. This step comprises three sub-steps of descriptive statistical analysis, multiple linear regression model, and bootstrap. Descriptive statistical analysis aims to provide a preliminary evaluation of the data by quantifying the mean, median, minimum, and maximum values. The step also checks the correlation coefficient between independent and dependent variables through the correlation coefficient matrix. After that, the multiple linear regression is applied to model the link between customer satisfaction and different factors of service quality. Bootstrap is then applied to quantify the weighting contribution of each factor to the customer satisfaction of each group of customers and the overall customer satisfaction.

Step 3. Results. There are two types of results being obtained. First, the customer satisfaction scores are analyzed by five criteria across four customer groups and the overall satisfaction score. Second, the study reports the criteria set of customer satisfaction (with weights of indicators) on electricity service quality in Hanoi. Based on these results, the most appropriate solutions can be proposed to improve the quality of electricity services, meeting the demand of customers in the most effective way.

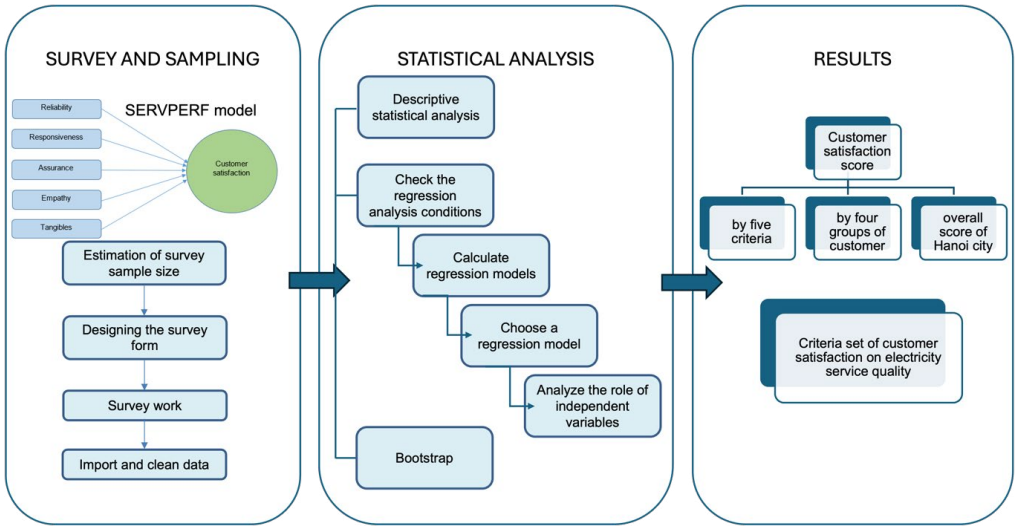


Fig. 1. Logical framework of the study

Rys. 1. Logiczna struktura badania

The calculation is implemented using R language, with RStudio software. Details on each step of sampling, calculation and analysis are presented in the following sections.



## 2.2. Sampling and survey

### **SERVPERF model**

SERVPERF is selected for the study as it is a quick and straightforward model to evaluate customer satisfaction with electric service quality and can be swiftly applied in practice to improve service quality. The SERVPERF model provides easy-to-evaluate information on the current situation, facilitates comparisons over time to report to management quickly, and identifies weaknesses that require immediate improvement. This helps businesses focus on enhancing actual service quality to prepare for the future competitive environment.

The SERVPERF model was proposed by Cronin and Taylor (1992). This model establishes the links between the service quality and perceptions of customers on different factors of the service quality after they buy and use the service. The better the customer feels about the product or service, the higher the quality of the product or service. There are five common factors of service quality, including tangibles, reliability, responsiveness, assurance, and empathy. In the electricity sector, these five factors correspond to business image, reliability of electricity supply, customer service, information to customers, and communication about safety and electricity prices. In this study, the quality of electricity service is described by applying the following Equation:

$$SQ_i = \sum_{j=1}^k P_{ij} \quad (1)$$

where:

$SQ$  – quality of electricity service perceived by customer  $i$ ,

$k$  – the number of factors,

$P_{ij}$  – the perception of individual  $i$  on the performance of electricity service regarding factor  $j$ .

### **Estimation of sampling size**

The SERVPERF model is applied to the study to estimate the sample size and design the questionnaire. According to the study of Harris (1985), the appropriate sample size to apply multiple (variable) regression analysis must be equal to the number of independent variables plus at least 50. Hair et al. (2014) suggested that the minimum sample size should follow the ratio 5:1, that is, five observations for one independent variable. Ideally, the sample size should be at a 50:1 ratio. In such a case, the ideal sample size of this study should be 250 samples for each group of customers. There are four groups of customers, including administration, residents, industry, and commerce; therefore, the total number of samples is 1000.

### **Design of survey form and survey work**

A survey form is designed, including 22 questions, regarding five factors of electricity service quality (presented in Table 2). The attributes of customer satisfaction are adapted from the five attributes of the SERVPERF model. Finally, 22 questions have been developed relevant to these five attributes.

These survey questions are selected based on the detailed content of the SERVPERF model and the characteristics of the electricity service. According to this model, there are two steps to determine the survey questions, including determining the evaluation criteria and determining specific questions in the criteria. Determining the evaluation criteria involves a comparison of the available criteria in the model with the characteristics of the electricity enterprise. Specifically, the model has five criteria:

- ◆ Tangibles: expressed through the appearance and uniform of service staff and equipment serving the service.
- ◆ Reliability: expressed through the ability to perform compatible and timely services the first time.
- ◆ Responsiveness: expressed through the desire and readiness of subordinates to deliver services to customers in a timely manner.
- ◆ Service capacity (assurance): demonstrated through professional qualifications and polite, enthusiastic service to customers.
- ◆ Empathy (empathy): showing care and concern for each customer.

Propose five factors of electricity industry service quality as follows:

Tangibles: Business image (4 questions)

Reliability: Reliability of electricity supply (5 questions)

Responsiveness: Customer service (4 questions)

Assurance: Information to customers (4 questions)

Empathy: Communication about electricity safety and prices (5 questions)

The determination of specific questions in the groups is also determined according to the above method.

In addition, to improve the authenticity of the questionnaire, the process of selecting criteria and specific questions is conducted in consultation with experts and customers before the official release. The experts were asked to correct technical and professional issues, and the customers were asked to make sure the questions are simple and easy to understand and answer.

The questions are scored using the Likert scale. The Likert scale measures the level of perception and opinion of the survey participants on a specific issue. It has the advantages of being easy to use and understand. By using the Likert scale, data is quantified, and attitudes and emotions are converted into measurable data, making it an effective statistical analysis tool and widely applied in many fields such as psychology, marketing, medicine, education, and management. Due to its flexibility, the Likert scale is applicable at various scales from small studies to surveys of thousands of people. It is also cost-effective and obtains the participants' responses quickly.

TABLE 2. Scale of the SERVPERF model

TABELA 2. Skala modelu SERVPERF

No	Service quality factor	Definition	Question
1	Tangibles (Business image)	Appearance of facilities, equipment, personnel, and communication materials	1. Up-to-date equipment and technology 2. Visually appealing facilities 3. Staff are well dressed and present neatly 4. Facilities are appropriate to the type of service
2	Reliability (of electricity supply)	Ability to perform promised services reliably and accurately	5. Do things on time as promised 6. Be empathetic and reassuring to customer problems 7. Demonstrate reliability 8. Provide services on time 9. Keep accurate records
3	Responsiveness (Customer service)	Willingness level to help customers and provide prompt service	10. Always inform when service will be performed 11. Fast service performance 12. Staff is always ready to help customers 13. Always respond to customer requests
4	Assurance (Information to customer)	The knowledge, courtesy of the staff and their ability to convey trust and confidence	14. Customers can trust the staff 15. Customers feel safe when doing business 16. Staff should be polite 17. Staff are well trained
5	Empathy (Communication about safety and electricity prices)	Ability to provide personal attention and care to customers	18. Always look forward to serving customers 19. Always care about customers 20. Employees always want to know customers' needs 21. Always care about customers' best interests 22. Arrange working hours convenient for customers

The authors of the paper organized the survey activities. After the survey form was designed, it was directly handed to the customers by the survey team. The survey team includes the final-year students at the Electric Power University. Students with knowledge of the electricity sector can explain the survey form and guide customers in filling it out. After that, the data were extracted from the answered forms, and the results were analyzed by the authors.

In order to ensure the ethical principles and prevent the conflict of interest, the survey team and participating customers were selected with these requirements: (1) do not work directly or indirectly at the electricity company of Hanoi city (EVN Hanoi); (2) are not the relatives of employee of EVN Hanoi. The survey team received training on selecting customers, conducting surveys, and explaining questionnaires to them. Besides, the information of participating customers is kept confidential.

The survey was conducted in 30 districts of Hanoi City in September 2022. Hanoi city is the capital city of Vietnam with an area of 3,359.82 km<sup>2</sup> (MONRE 2022), a population of 8.4 million people, including 12 urban districts, 17 rural districts, and one district-level town (GSO 2023). Hanoi has 2.2 million households and 144 thousand businesses (GSO 2023). Most national governmental agencies, socio-economic organizations, foreign-invested businesses, and foreign-funded organizations are located in Hanoi.

As mentioned before, there are 250 survey forms for each group of customers, covering 30 districts; therefore, there are about eight to ten forms for each group of customers in each district. Apart from the geographical distribution, the survey ensures that the distribution ratio of electricity consumption (in kWh per month) of the consumers was relatively even in each survey group.

### **Import and clean data**

The satisfaction scores, as perceived by the customers, collected from the survey forms, are entered into the Excel file. The scores are entered twice independently and compared to ensure the correctness of the survey results. Data cleansing is implemented for correcting or deleting inaccurate, corrupted, incorrectly formatted, duplicate, or incomplete data to obtain a complete set of data.

## **2.3. Multiple linear regression model**

The multiple linear regression (MLR) model is a statistical technique to model the relationship between a dependent variable and multiple independent variables. It is an important tool in data analysis and prediction. In this study, the model is applied to determine the linear relationship between customer satisfaction and the corresponding coefficients. The basic equation of an MLR model is described below (Kutner et al. 2005):

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + \varepsilon \quad (2)$$

where:

- $Y$  – the dependent variable,
- $X_1, X_2, X_k$  – the independent variables,
- $\beta$  – the intercept,
- $\beta_1, \beta_2, \beta_k$  – the regression coefficients,
- $\varepsilon$  – the random error.

Important assumptions of the model:

- ◆ Linear relationship: each relationship between the independent variable and the dependent variable is a linear relationship.
- ◆ Constant error variance: the error variance is constant within the range of the independent variable.
- ◆ Normal distribution of the residuals (errors): the distribution of the residuals follows the normal distribution law.
- ◆ Independence of the errors: the errors are independent of each other.

### **Check the regression analysis conditions**

Checking the independent and dependent variables satisfies the linear regression assumptions. Regression condition testing is performed for each pair of dependent and independent variables. Test contents include checking the normal distribution of data, invariant variance, linear correlation, and outliers.

### **Calculate regression models**

Calculating linear regression functions with data sets that meet analysis requirements. Types of linear regression models include Log-linear, Log-lin, Lin-log, and inverse (reciprocal model).

### **Choose a regression model**

Preliminarily select the best models among the calculated models that satisfy the initial testing criteria, such as R-sq, Adj R-sq, t-test, F-test, and are eligible for comparative analysis. The selected model is determined based on the results of model quality testing such as F test (P-value), Median, Residual standard error, DW (durbinWatsonTest) to test the autocorrelation phenomenon, VIF (Variance Inflation Factor) to test multicollinearity, AIC (Akaike Information Criterion) to test model quality, BIC (Bayesian Information Criterion) to test model quality.

### **Analyze the role of independent variables**

Calculating the 95% confidence interval for the regression coefficients. The shorter this confidence interval, the more reliable the model's estimated parameters.

## **2.4. Bootstrap method**

The Bootstrap method, which was introduced by Bradley Efron in 1979, is a powerful statistical technique based on resampling, used to estimate the precision of statistical estimates (Roca-Pardinas et al. 2009). The basic principles of Bootstrap include sampling with replacement from the original data set to create multiple Bootstrap data sets, calculating statistics of interest (e.g., mean, variance) on each Bootstrap data set, and using the distribution of these statistics to estimate precision or confidence intervals. In the Bootstrap method, the resampling process is repeated many times (usually 1000 or 10000 times) to create many Bootstrap samples. Each Bootstrap sample is used to calculate the statistic of interest, creating a distribution of that statistic, so the precision or confidence interval can be estimated.

Sampling with replacement is a sampling technique in which each element selected from the original data set can be selected multiple times while creating a new sample. Once an element is selected and recorded in the new sample, it is “replaced” in the original data set so that it can be selected again in subsequent samplings. The steps are:

1. Start with an original data set of  $n$  elements.
2. Randomly select an element from the original data set.

3. Record the selected element in a new sample.
4. “Replace” the selected element in the original data set.
5. Repeat steps 2–4 until the new sample has  $n$  elements.

Important feature: The new sample is usually the same size as the original data set but may be different depending on the research purpose. Each element in the original data set has a probability of being selected  $1/n$  in each sampling, independent of previous selections. The new sample may contain repeated elements and may be missing some elements from the original data set.

This study uses the Bootstrap method and LMG (Lindermann, Merenda Gold) measure to estimate  $R^2$  for each independent variable of the selected model (Bi 2012). This estimation shows the percentage contribution of independent variables to explain fluctuations in the dependent variable. In this study, the Bootstrap method identifies the contribution (or the weights) of each criterion to the overall satisfaction index (in percentage). These contributions indicate which criterion has the most critical role and the order of importance of each in contributing to the total index.

The LMG method is a statistical technique used to determine the relative importance of independent variables in a linear regression model, especially effective when the variables are correlated. The LMG method calculates the relative importance indices of input variables through the decomposition of  $R^2$  for linear regression models. It calculates the relative contribution of each predictor variable to  $R^2$ , considering the order in which the predictor variables appear in the model. The variance decomposition principle involves dividing the total explained variance ( $R^2$ ) into the contributions of each variable, assigning each a positive importance value, and ensuring that the sum of these values equals the  $R^2$  of the model. When variables are correlated, the order in which they are entered into the model affects the contribution; LMG averages all possible orders to get fair results. In case of multicollinearity problem, before applying Bootstrap, the study performed linear regression analysis under conditions with independent and dependent variables; the linear regression functions were also tested for multicollinearity. The VIF test for different groups of customers, such as administration, resident, industry, and commerce, shows the corresponding VIFs in the ranges of (2.53 to 4.44), (3.09 to 3.89), (3.37 to 4.91), and (2.85 to 6.25). These values are mostly less than 5, only a few are equal to 6.25, so it can be considered that the multicollinearity condition is satisfied.

The analysis methods in the study include linear regression analysis and the Bootstrap method. Linear regression analysis is used to evaluate the satisfaction of customer groups. With survey data of four customer groups, linear regression analysis evaluates whether the data meet the conditions for linear regression analysis. After determining the best regression function, tests need to be used to evaluate the quality of the model. The Bootstrap method is used to determine the percentage of contribution of criteria to the total overall customer satisfaction, thereby determining the role of criteria groups and orienting recommendations to improve customer satisfaction. Both linear regression analysis and Bootstrap are conducted using the R software.

## 3. Results and discussion

### 3.1. Electricity consumption characteristics of surveyed customers

The four groups of customers, including administration, residents, industry, and commerce, have distinct electricity consumption characteristics, such as purposes of electricity consumption, peak hours by days and by seasons, as well as the amount of electricity consumed. Specifically, the administration group uses electricity for state management purposes, providing public services such as administrative units, hospitals, nurseries, kindergartens, and schools. Resident groups use electricity for daily living purposes such as lighting, cooking, heating, and cooling. Industry groups utilize electricity for manufacturing activities, including enterprises, factories, and small production households. Commerce groups use electricity for business activities, such as shops, restaurants, and hotels. Detailed information on the electricity consumption characteristics of these customer groups is presented in Table 3, and Figure 2 illustrates the amount of electricity consumption of the surveyed customers.

TABLE 3. Electricity consumption characteristics by groups of customers

TABELA 3. Charakterystyka zużycia energii elektrycznej według grup odbiorców

Customer	Daily load characteristics			Annual load characteristics
	peak hours	non-peak hours	characteristics	
Resident	5.00 to 8.00 18.00 to 22.00	22.00 to 5.00 of the next day	Two peak loads, with clear difference between hours during the day	Clear difference between seasons, with higher demand in summer
Administration	7.00 to 8.00 11.00 to 13.00 16.00 to 17.00	17.00 to 7.00 of the next day	Three peak loads, with small difference among loads	Stable loads during the year
Industry	6.00 to 14.00 14.00 to 22.00 (average)	22.00 to 6.00 of the next day	Loads are stable, with small difference between hours during the day, and depend on work shifts and production cycles	Depends on annual production plans, market demand on the product
Commerce	8.00 to 11.00 16.00 to 19.00	22.00 to 6.00 of the next day	Two peak loads, with clear difference between hours during the day	Clear difference among days and seasons. Largely depend on socio-economic events.

The amounts of electricity consumed monthly by each group of customers are considerably different (as in Fig. 2). The majority of the resident customers (69.4%) consume less than 500 kWh per month. In contrast, only a small number of commerce, industry, and administration

customers (less than 30% of survey customers) consume less than 500 kWh. More than 40% of commerce customers have a monthly electricity consumption of 500 to 2,000 kWh, accounting for the most significant part of the surveyed customers of the commerce group. The patterns of monthly electricity consumption among industry and administrative customers are relatively similar, with the largest share of customers using 500 to 2,000 kWh (31% for industry and 35% for administration), followed by customers using more than 5,000 kWh (23 and 19% for industry and administration, respectively).

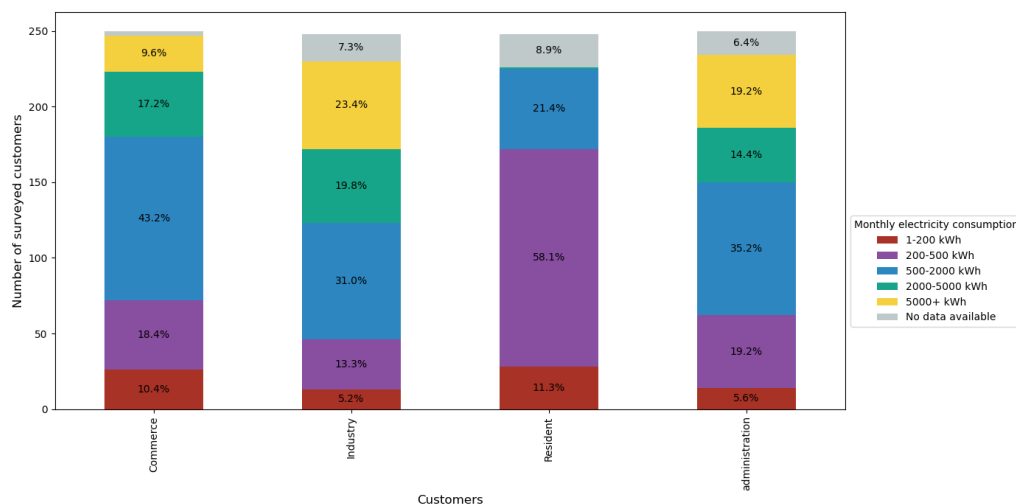


Fig. 2. Monthly electricity consumption of surveyed customers

Rys. 2 Miesięczne zużycie energii elektrycznej przez ankietowanych klientów

### 3.2. Importance of customer satisfaction indicators

By applying Bootstrap, the results of the percentage contribution of the criteria to the overall customer satisfaction index are obtained. The results indicate the different importance of the criteria to customer satisfaction. Even for the same criteria, the importance is different for each group of customers (as presented in Fig. 3). Among the criteria, the business image plays an important role in customer satisfaction across all four groups, ranging from 21.16 to 21.88%. Meanwhile, power supply reliability contributes the smallest part to the customer satisfaction, for all four groups of customers, accounting for around 18%. However, there is a small variance among groups of customers, in which residential and industrial customers seem to appreciate the power supply reliability more than the two remaining groups.



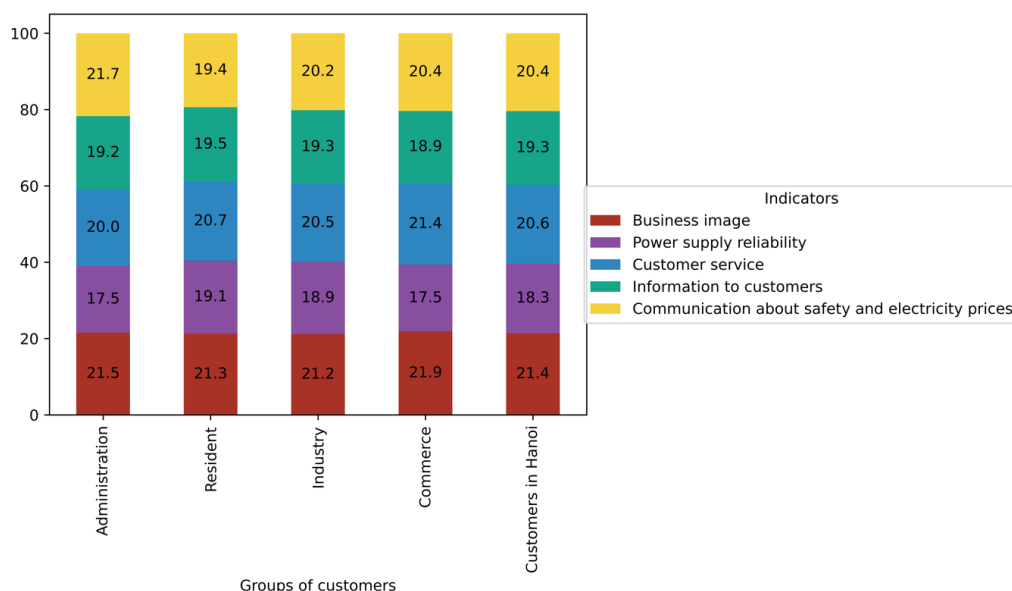


Fig. 3. Weighting set of customer satisfaction indicators [%]

Rys. 3. Waga zestawu wskaźników satysfakcji klientów [%]

Regarding the groups of customers, while the administration considers communication about the safety and electricity price, and business image are the top two important criteria, contributing to 21.71 and 21.51% of the total customer satisfaction, the three remaining groups perceive that business image and customer service are the most important criteria. Industrial and commercial customers perceive communication about safety and electricity price as an important indicator, but slightly less important than customer service.

### 3.3. Satisfaction of four groups of customers

The customer satisfaction score is valued from 1 to 5. The average score of each indicator is the mean value of all customers' assessment scores by groups of customers. In general, the customers highly appreciate the quality of electricity industry services, with customer satisfaction scores ranging from 4.0 to 4.47, depending on various groups of customers. The average scores of customer satisfaction are presented in Table 4.

The satisfaction of administrative customers is 4.47 out of 5. The Power supply reliability has the highest score of 4.52, followed by an average score of Information to customers of 4.50, Customer service of 4.49, Business image of 4.42, and Communication about safety and electricity prices of 4.41.

TABLE 4. Average score results of customer satisfaction by group

TABELA 4. Średnie wyniki satysfakcji klientów według grup

Indicators	Administration	Resident	Industry	Commerce
Business image	4.42	4.34	4.34	4.36
Power supply reliability	4.52	4.40	4.43	4.47
Customer service	4.49	4.40	4.39	4.43
Information to customers	4.50	4.42	4.43	4.44
Communication about safety and electricity prices	4.41	4.37	4.35	4.31
Customer satisfaction	4.47	4.39	4.39	4.40

The residential customers evaluate the quality of electricity industry services lower than the administration customer group, with an average score of 4.39, in which the Information to customers criterion has the highest score of 4.42, followed by Power supply reliability. Customer service is valued at 4.40, Communication about safety and electricity prices is valued at 4.37, and Business image is valued at 4.41.

The industrial customers have the same satisfaction score on the quality of electricity industry services as the residential customers. The Power supply reliability and Information to customers have the highest score of 4.43, followed by Customer service, which is 4.39. Communication about safety and electricity prices is 4.35, and the Business image is 4.34.

The commercial customers evaluate the quality of electricity industry services at an average score of 4.4. The criteria of Power supply reliability and Information to customers have the highest scores of 4.47 and 4.44, respectively. Besides, Customer service is 4.43, Business image is 4.36, and Communication about safety and electricity prices is 4.31.

Besides, the customer satisfaction scores are converted into a scale from 0 to 100, as presented in Figure 4, to observe the slight differences among groups of customers and satisfaction indicators. The satisfaction scores of all groups for the five indicators are relatively high, in the range of 85 to 91. In general, the administration has the highest satisfaction in all five indicators, from 88.2 to 90.4. Specifically, the residential and industrial customers have similar ranges, from 86.8 to 88.0 for residential and from 86.7 to 88.6 for industrial. The satisfaction scores of commercial customers range from 86.1 to 88.9.

### 3.4. Satisfaction in Hanoi city

The customer satisfaction with electricity service quality in Hanoi is relatively high, at 4.41 out of 5. By groups of customers, the administrative customers have the highest

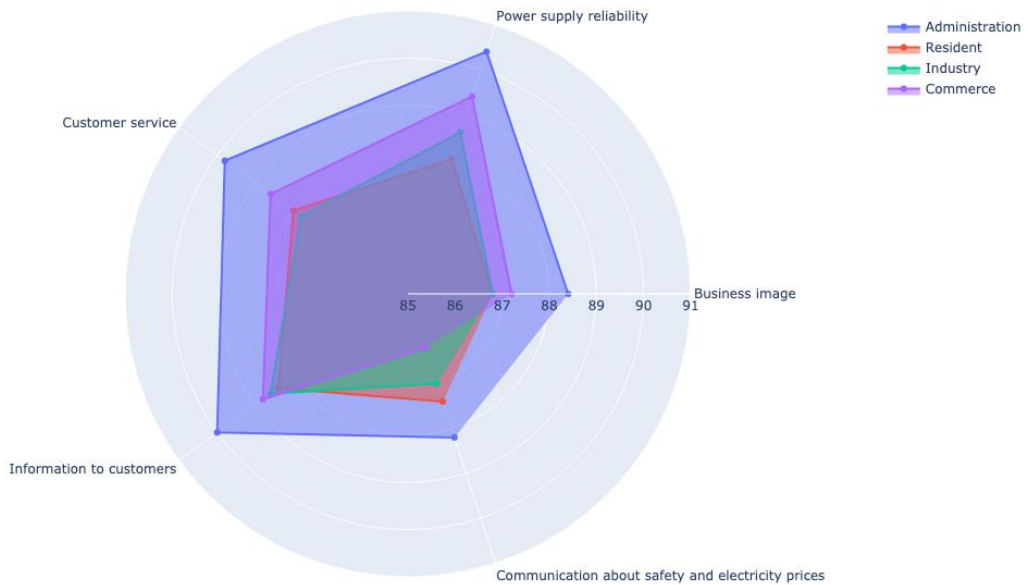


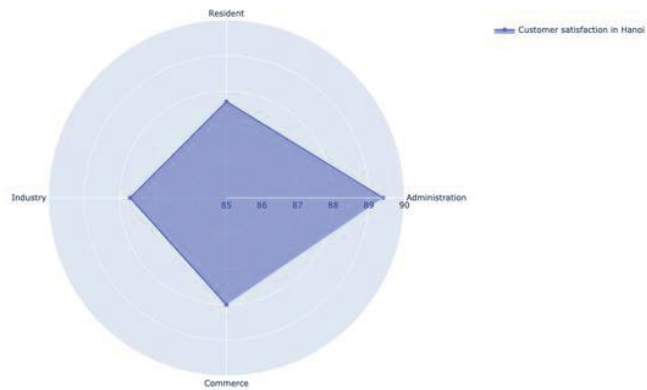
Fig. 4. Satisfaction scores of four groups of customers

Rys. 4. Wyniki satysfakcji czterech grup klientów

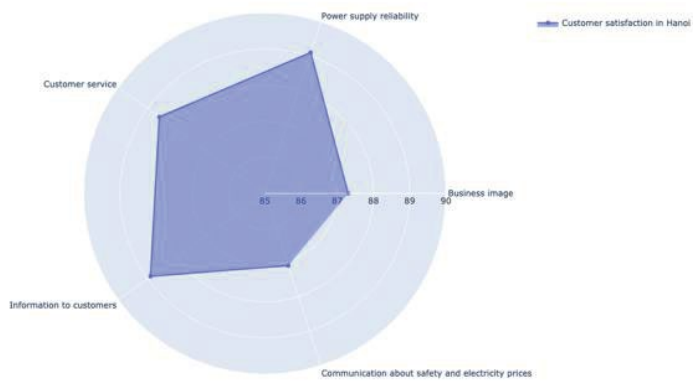
average score of 4.47, followed by commerce, resident, and industry, at 4.40, 4.39, and 4.39, respectively (Fig. 5a). By indicators, the average scores of power supply reliability, information to customers, customer service, business image, and communication about safety and electricity prices are 4.46, 4.45, 4.43, 4.36, and 4.36, respectively (Fig. 5b). There is not much difference between the groups of customers, as well as the indicators of satisfaction (as illustrated in Fig. 5c).

### 3.5. Discussion

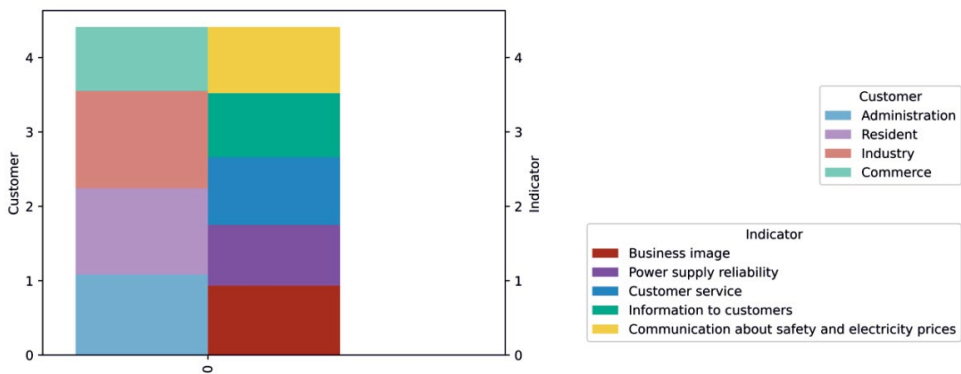
In general, customer satisfaction scores are high for all customer groups, 4.39 out of 5.00 or higher. The EVN Hanoi is very concerned about its customers, and vice versa, the customers highly appreciate the company's activities to improve the service quality. The company enhanced power supply reliability by completing the information technology infrastructure system, applying science and technology in business operations and grid control, improving service and electricity supply, and providing customers with timely and accurate information. EVN Hanoi is effectively leveraging digital technologies, the Internet of Things, and big data to facilitate continuous communication with its customers. The widespread deployment of EVN Hanoi and E-point apps on mobile devices provided customers with their daily electricity consumption



(a) Customer satisfaction by four customer groups



(b) Customer satisfaction by indicators



(c) Contribution of customer groups and indicators to the overall customer satisfaction

Fig. 5. Customer satisfaction on electricity service quality in Hanoi

Rys. 5. Zadowolenie klientów z jakości usług energetycznych w Hanoi

indicators. Therefore, the customers have a clear understanding of electricity consumption, reducing unnecessary doubts and questions, especially during peak summer months.

Besides, EVN Hanoi connected with several banks and intermediary organizations to facilitate the payment of electricity bills. Every month, the company's Customer Care Center regularly makes random calls to customers, soliciting feedback on the attitude of their technical employees and telephone operators towards the customers' requests and demands. These activities of EVN Hanoi have been recognized and highly appreciated by its customers.

The average scores on satisfaction indicators, the satisfaction of each customer group, and the entire city are high, but they are relatively different. The administration has the highest satisfaction score of 4.47 out of 5.00, outperforming the remaining groups, such as commerce (4.40), resident, and industry (4.39 for both groups). The administrative customers are national and local agencies and organizations, which have qualified and professional electricity officers (and engineers). These officers have proficient technical expertise, so they quickly recognize and appreciate the efforts of the power company, especially in terms of power supply reliability.

Industry, commerce, and residents have lower satisfaction scores (compared to administration), which is likely due to the fact that these customers were affected by the COVID-19 pandemic during 2022, when the survey was conducted. The pandemic caused economic difficulties, affecting their income and making it difficult to pay bills, including electricity bills. On the other hand, the EVN Hanoi faced many difficulties in 2020 due to constrained power plant supply. During this year, some power plants generated less electricity than expected, which caused power outages and power cuts in some places. Unfortunately, the existing data is inadequate to integrate COVID-19 as a variable in the model. It is recommended that future studies incorporate this variable into the model to understand the impacts of global socio-economic events, such as COVID-19, on customer satisfaction and the response of service providers.

The difference in satisfaction levels of customer groups is assessed according to the observed trend. The administration group is the most satisfied, with satisfaction levels higher than those of the remaining groups, including residents, industry, and commerce. For this research, a t-test can be applied to each pair of customer groups. The results show that the p-value of the evaluation pairs is higher than 0.05. For example, the Administration and Resident groups have a p-value of 0.08437; the Administration and Industry groups have a p-value of 0.08875... This significance level is quite close to 0.05, which can be considered "marginally significant". For exploratory research, a p-value of 0.1 is acceptable.

Figure 6 shows that the two indicators of business image and communication on safety and electricity prices have the lowest customer satisfaction levels, which are true for the whole Hanoi city as well as four groups of customers. In particular, the commercial customers rated the communication on safety and electricity price as the lowest value of 4.31 out of 5.00. The indicators of Power supply reliability and customer information are rated as the highest, with administrative customers evaluating the quality of electricity supply at 4.52 out of 5.00. Most customer satisfaction scores are around 4.4. The EVN Hanoi needs to improve its customer service efficiency to increase customer satisfaction scores in such criteria as Business image and Communication about safety and electricity price.

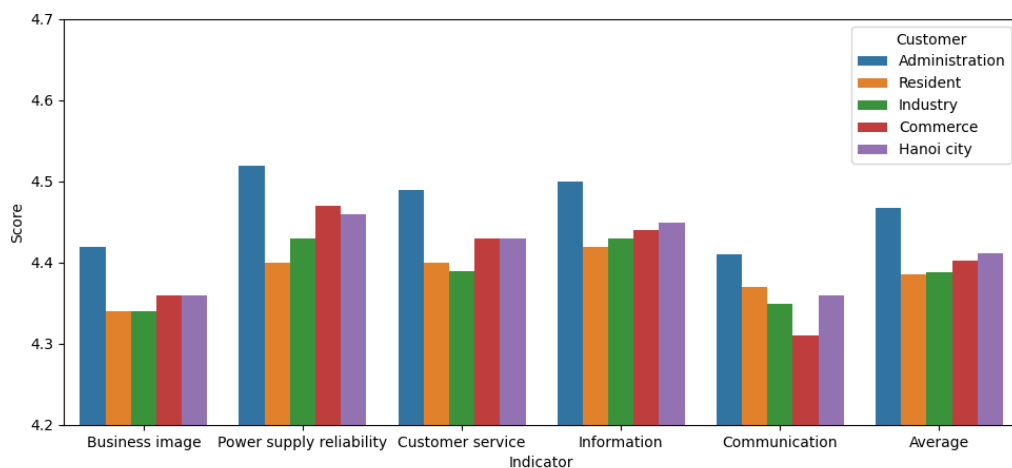


Fig. 6. Customer satisfaction scores of EVN Hanoi

Rys. 6. Wyniki badania satysfakcji klientów EVN Hanoi

Regarding the importance of each indicator and groups of customers to the overall satisfaction, there is no significant difference between the percentage points of each indicator contributing to the overall customer satisfaction, all of which are close to 20%. Thus, the roles of these indicators are not significantly different. In contrast, the contributions of four groups of customers to the overall satisfaction of Hanoi city are relatively different. Specifically, the industry accounts for 29.77% of the overall satisfaction, followed by resident (at 26.46%) and administration (at 24.21%). The commercial customers account for the smallest share, at 19.56%. In such a case, the most effective way to improve customer satisfaction for EVN Hanoi is to aim at the industrial and residential customers. Besides, efforts need to be set on improving all five indicators, especially the two weaknesses of business image and communication on safety and electricity price.

Some recommendations to improve customer satisfaction include:

**Business image:** continue to improve the activities that have been implemented such as developing mobile applications for paying electricity bills, searching for and reporting incidents, setting up a 24/7 customer care hotline with fast response time, simplifying administrative procedures, reducing waiting time, conducting periodic surveys on customer satisfaction, monitoring feedback on social networks and the press, listening and promptly handling customer complaints.

**Communication on safety and electricity prices:** publicly and transparently disclose information on electricity prices and development plans. Create educational materials on electricity saving and electrical safety using multiple communication channels: website, social networks, newspapers, etc.

**Improve the quality of electricity supply:** modernize infrastructure, increase reliability, control electricity quality, periodic maintenance, develop human resources, etc. Examples

of infrastructure modernization include fabric improvement and enhancing the safety of the electricity supply in public areas with poor infrastructure, such as traditional markets and the distribution network in residential areas.

For the Vietnamese electric power sector, two local (provincial) agencies, including the Provincial Power Company and the Provincial Department of Industry and Trade, are responsible for improving the electric power service quality. The Department of Industry and Trade manages, supervises, and supports the legal and policy framework for the power sector, while the Provincial Power Company implements recommendations to improve customer satisfaction. The Power Company will identify indicators, propose issues that need improvement, and organize implementation. In most cases, the above-mentioned indicators and recommendations will be determined by a consultant working under the contract with the Power Company or the Department of Industry and Trade.

## Conclusions

The study on satisfaction of four customer groups, such as administration, residents, industry, and commerce, provides insights into the contributions of each customer group and satisfaction indicator to the overall customer satisfaction score in Hanoi. Each customer group evaluates the service quality of Hanoi EVN by five criteria: business image, power supply reliability, customer service, information to customers, and communication about safety and electricity prices. The results of the study suggest solutions to improve the electricity service quality according to the specific criteria or customer groups.

There is a relatively significant difference in the perception of four customer groups on electricity service quality according to five criteria. The administration customer group has the highest satisfaction level (4.47/5 points), followed by the commerce group (4.41/5 points); the two groups of industry and resident have the same satisfaction level of 4.39/5 points. The satisfaction score of Hanoi city is 4.41/5 points.

The administration group gives the highest score for the power supply reliability (4.52/5), and the lowest score for the communication of the power company on safety and electricity prices (4.41/5). The resident group gives the highest score for the information to customers (4.42/5), and the lowest score for the business image (4.34/5). The industry group gives the highest score for the power supply reliability and information to customers (4.43/5), and the lowest score for the business image (4.34/5); the commerce group gives the highest score for the power supply reliability (4.47/5), the lowest score for the communication of the power company (4.31/5). In summary, the quality of electricity (power supply reliability) is the factor that receives the highest rate from customers (average 4.46/5), followed by information to customers (4.45/5), and customer service (4.43/5). Business image and communication of the power company receive the lowest rate (average 4.36/5).

Considering the contribution of satisfaction indicators in customer groups helps the power company identify the critical aspects to improve its service quality. The research results show that the importance of each indicator (for each group of customers as well as for the whole city) is different. For the whole city, business image plays the most important role in contributing to 21,39% of the overall customer satisfaction score, followed by customer service and communication (20.58 and 20.39%). Information to customers and power supply reliability play a small contribution to the overall satisfaction (19.34 and 18.30%).

It is suggested that the study on customer satisfaction with electricity service quality should be performed annually or every six months. The results of the annual study will help the power company monitor customer satisfaction according to any change in their service quality, and eventually further improve the power service quality to meet the demand of all customer groups.

The Authors have no conflicts of interest to declare.

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## Zadowolenie klientów z jakości usług energetycznych w Hanoi w Wietnamie

### Streszczenie

Ocena zadowolenia klientów z jakości usług energetycznych dostarcza ważnych rozwiązań pozwalających poprawić jakość usług, zwłaszcza na konkurencyjnym rynku energii elektrycznej. W Wietnamie konkurencyjny rynek detaliczny energii elektrycznej znajduje się w początkowej fazie rozwoju, co wymaga poprawy jakości usług i zwiększenia zadowolenia klientów w celu uzyskania przewagi konkurencyjnej. W artykule przedstawiono zestaw wskaźników służących do oceny zadowolenia klientów w sektorze energetycznym w Hanoi w Wietnamie w podziale na cztery grupy klientów: administrację, mieszkańców, przemysł i handel. Zastosowano nowatorską metodę badania, polegającą na kwantyfikacji i ocenie zadowolenia klientów z usług energetycznych poprzez połączenie modelu SERVPERF do stworzenia zestawu pytań ankietowych, statystyk opisowych i metod regresji liniowej do analizy wyników oraz metody Bootstrap do określenia wag wskaźników. Wyniki badań wykazały wyraźną różnicę w ocenie zadowolenia klientów według pięciu kryteriów jakości usług i czterech grup klientów. Najwyższy poziom zadowolenia odnotowano w grupie klientów z sektora administracji (4,47/5,00 punktów), a następnie w grupie klientów z sektora handlu (4,41/5,00 punktów); dwie grupy klientów z sektora mieszkaniowego i przemysłowego uzyskały ten sam poziom oceny wynoszący 4,39/5,00 punktów. Ogólny wynik satysfakcji klientów w mieście Hanoi wyniósł 4,41/5,00 punktów. Ponadto wagi wskaźników również różniły się wyraźnie. Najważniejszą rolę odgrywa wizerunek firmy, który ma 21,39% udziału w wyniku satysfakcji klientów, a następnie obsługa klienta i komunikacja (20,58 i 20,39%). Informacje dotyczące bezpieczeństwa i ceny energii elektrycznej oraz niezawodności dostaw energii elektrycznej mają niewielki udział w ogólnej satysfakcji klientów (odpowiednio 19,34 i 18,30%). Analiza przeprowadzona w niniejszym artykule sugeruje, że Hanoi Electricity Company powinna skupić się na najważniejszych wskaźnikach oraz wskaźnikach o najniższym poziomie satysfakcji, np. wizerunku firmy oraz informacjach dotyczących bezpieczeństwa i ceny energii elektrycznej.

**SŁOWA KLUCZOWE:** zadowolenie klientów, jakość usług energetycznych, konkurencyjny rynek energii elektrycznej, SERVPERF, Bootstrap