JOURNAL OF MANAGEMENT AND BUSINESS SOLUTIONS

Prioritization of Stakeholder and Customer Requirements in the Compressed Natural Gas (CNG) Sector: A Hybrid Delphi-Kano-AHP Approach (Case Study: Iran)

1. Shapoor. Aliee : Department of marketing management, Za.C., Islamic Azad University, Zanjan, Iran
2. Arshad. Farahmandian*: Department of Management, Za.C., Islamic Azad University, Zanjan, Iran
3. Abolfazl. Moghadam: Department of marketing management, Za.C., Islamic Azad University, Zanjan, Iran

*corresponding author's email: 4280924015@iau.ac.ir

ABSTRACT

Increased attention to cleaner fuels has heightened the policy significance of Compressed Natural Gas (CNG) in road transportation; however, declining adoption rates and the presence of operational constraints indicate that stakeholder and customer requirements have not been sufficiently prioritized. This study proposes an integrated framework for identifying and prioritizing key requirements in the CNG sector. In the first step, an initial list of requirements is refined using the Delphi method and expert consensus. In the second step, the Kano model is employed to categorize the refined requirements into three categories—basic, performance, and excitement—based on their impact on user satisfaction. In the third step, the Analytic Hierarchy Process (AHP) is utilized to extract priority weights for the Kano categories and selected requirements. Results indicate that basic requirements receive the highest priority weights, followed by excitement and performance requirements; this finding underscores the critical role of foundational service and accessibility factors in CNG policy and operations. The proposed framework provides practical guidance for policymakers and CNG operators to allocate resources toward the most impactful requirements, thereby enhancing user satisfaction and adoption outcomes.

Keywords: Compressed Natural Gas (CNG); stakeholder requirements; customer needs; Kano model; Delphi method; Analytic Hierarchy Process (AHP); green marketing.

Introduction

The global energy transition has intensified focus on cleaner transportation fuels, positioning Compressed Natural Gas (CNG) as a pivotal solution for reducing greenhouse gas emissions and enhancing energy security (1). CNG's lower carbon footprint compared to conventional gasoline and diesel, coupled with its potential to mitigate urban air pollution, has driven policy adoption across emerging economies (2). In Iran, where transportation accounts for over 40% of national energy consumption and 70% of urban air pollution (3), CNG represents a strategic asset for achieving climate commitments under the Paris Agreement and advancing national energy security (4). Despite significant policy incentives—including subsidies, tax exemptions, and infrastructure investments—CNG adoption rates in Iran remain suboptimal, with vehicle penetration lagging behind potential (5, 6). This paradox underscores a critical gap: while CNG's technical and environmental viability is well-documented,

Article history:
Received 26 November 2025
Revised 04 March 2026
Accepted 09 March 2026
Published online 01 May 2026

How to cite this article:
Aliee, S., Farahmandian, A., & Moghadam, A. (2026). Prioritization of Stakeholder and Customer Requirements in the Compressed Natural Gas (CNG) Sector: A Hybrid Delphi-Kano-AHP Approach (Case Study: Iran). *Journal of Management and Business Solutions, 4*(3), 1-11. https://doi.org/10.61838/jmbs.255

its successful market integration hinges on aligning service delivery with nuanced stakeholder and customer requirements (7).

Iran's CNG sector faces multifaceted challenges that extend beyond infrastructure limitations. First, inconsistent fuel pricing and supply chain disruptions have eroded consumer trust, with public surveys indicating that 68% of potential adopters cite "unreliable access" as a primary barrier (6). Second, operational constraints—such as limited station coverage in peripheral regions and inadequate maintenance protocols—have diminished service reliability, directly impacting user satisfaction (8, 9). Third, policy frameworks often prioritize macroeconomic goals over granular customer experience, resulting in misaligned service attributes. For instance, while government initiatives emphasize CNG's environmental benefits (3), consumers consistently rank *accessibility* and *cost predictability* as higher-priority needs than emissions data (7). This misalignment reflects a broader systemic issue: stakeholder requirements in Iran's CNG sector remain inadequately categorized, prioritized, and operationalized within policy and service design (10).

The Kano model offers a robust theoretical lens for dissecting customer requirements into three critical categories: *basic* (expected attributes that cause dissatisfaction if absent), *performance* (attributes where satisfaction scales linearly with quality), and *excitement* (unexpected features that generate delight) (7, 11). Empirical studies confirm that CNG adoption is significantly influenced by basic requirements (e.g., station availability, pricing stability) and excitement factors (e.g., eco-conscious branding, loyalty programs), while performance attributes (e.g., fuel efficiency metrics) exert secondary influence (11, 12). However, existing research in Iran has predominantly focused on technical or economic dimensions (e.g., station location optimization, cost-benefit analysis), neglecting the *qualitative* prioritization of human-centered requirements (8, 9). For example, while Dibavand (4) examines CNG's role in national security, and Vahhabpour et al. (3) assess environmental impacts, neither addresses how customer satisfaction drivers shape adoption outcomes. This gap impedes evidence-based resource allocation, as policymakers and operators lack a systematic method to distinguish between "must-haves" and "nice-to-haves" in CNG service design.

To bridge this gap, hybrid methodologies integrating qualitative and quantitative approaches are increasingly advocated. The Delphi technique, leveraging expert consensus to refine requirements, has proven effective in complex policy environments (13). When combined with the Kano model for requirement categorization and the Analytic Hierarchy Process (AHP) for weight derivation, this tripartite framework enables nuanced prioritization that accounts for both subjective expert judgment and objective customer impact (11, 12). Recent applications in sustainable mobility confirm that such integration outperforms single-method approaches in capturing multidimensional stakeholder needs (11, 12). For instance, Liu (11) demonstrated that a Kano-AHP hybrid framework improved electric vehicle charging station satisfaction by 27% through targeted resource allocation to basic and excitement requirements. Similarly, Wang et al. (12) validated the framework's efficacy in cultural product design, highlighting its adaptability across sectors.

Iran's unique socio-technical context necessitates such a tailored approach. The country's CNG market is characterized by a dual-sector dynamic: state-owned operators dominate infrastructure, while private entities manage retail services (4). This fragmentation complicates stakeholder coordination, as government priorities (e.g., energy security) often diverge from consumer expectations (e.g., convenience, cost transparency) (5). Furthermore, Iran's high population density in urban centers like Tehran intensifies demand for accessible CNG stations, yet spatial planning studies reveal significant coverage gaps in low-income districts (9). Without a structured method to prioritize requirements across these dimensions, investments risk misalignment—such as overemphasizing station quantity over service quality, which fails to address core customer pain points (8).

Theoretical and empirical foundations further justify this integrated approach. The Kano model's ability to distinguish between *dissatisfiers* (basic requirements) and *satisfiers* (performance/excitement) directly addresses the "unmet needs" paradox in CNG adoption (7). AHP's hierarchical weighting then quantifies these categories' relative importance, enabling data-driven decisions (12). Crucially, fuzzy logic—employed to handle expert subjectivity in Delphi rounds—enhances robustness by accommodating linguistic ambiguity in qualitative assessments (11, 12). This is particularly relevant in Iran, where cultural nuances influence stakeholder perspectives (e.g., trust in state versus private operators) (14). Recent studies confirm that fuzzy Delphi-AHP hybrids reduce consensus uncertainty by 32% compared to traditional methods, making them ideal for complex, multi-stakeholder contexts (10).

Despite these advances, no study has applied this integrated framework to Iran's CNG sector. Prior research has either focused narrowly on infrastructure (8, 9) or analyzed environmental impacts without linking them to customer experience (3). The absence of a unified prioritization mechanism leaves policymakers without a roadmap to optimize resource allocation. For example, while CNG's environmental benefits are well-documented (2), their translation into customer value remains unquantified—leading to underinvestment in high-impact areas like station accessibility (C14) or consumer trust-building (C14) (6). This disconnect is exacerbated by Iran's evolving energy policies, which increasingly emphasize *green marketing* and *customer-centric service models* (10, 14).

The proposed study addresses these critical gaps by developing and validating a hybrid Delphi-Kano-AHP framework specifically for Iran's CNG sector. It systematically identifies, categorizes, and weights stakeholder requirements using a two-phase expert consensus process, incorporating fuzzy logic to manage subjective judgments. This approach moves beyond descriptive analysis to deliver actionable insights for policymakers and operators—enabling them to allocate resources toward requirements with the highest impact on satisfaction and adoption. By grounding the framework in Iran's unique operational and cultural context, the study ensures practical relevance while contributing to global literature on sustainable mobility management.

In summary, the transition to CNG in Iran is not merely a technical or economic challenge but a *human-centered* one requiring precise alignment between service attributes and stakeholder expectations. Current policy efforts, though well-intentioned, lack the methodological rigor to prioritize requirements effectively, resulting in suboptimal adoption and resource utilization. This study synthesizes cutting-edge methodologies—Kano modeling, Delphi consensus, AHP weighting, and fuzzy logic—to create a scalable, evidence-based framework for transforming CNG service delivery in Iran.

The aim of this study is to develop and validate a hybrid Delphi-Kano-AHP framework for prioritizing stakeholder and customer requirements in Iran's CNG sector, thereby enabling targeted resource allocation to maximize user satisfaction and adoption rates.

Methods and Materials

This study, in terms of purpose, is of the fundamental-applied type, and in terms of research method, it is a mixed-method exploratory-descriptive (qualitative-quantitative) field study, conducted in three main stages. In the first phase, data were collected through questionnaires and interviews with 15 experts in the CNG field. Subsequently, thematic analysis was employed for data analysis, as detailed below. After coding and categorizing the information, the customer requirements list was filtered, and finally, using the Quality Function Deployment (QFD) method according to the specified four steps, the requirements were categorized and prioritized. In this section, 15 experts from the CNG industry were consulted. These individuals comprised private sector managers, specialists, and experienced government sector employees. Given the data collection approach, expert opinions, and the use of statistical and mathematical methods, the analysis in this study is a hybrid qualitative-quantitative approach.

The "Delphi technique" was utilized in the present study to rank the categories and items of the green marketing concept. Accordingly, the questionnaire was designed and finalized, then distributed to 15 experts, who were requested to provide their opinions regarding the items and categories. After calculating the average opinions of experts regarding the categories and items in the first round, a second-round questionnaire, including a column of the first-round average opinions, was distributed to facilitate consensus among the experts. Finally, the final opinions of the experts were summarized, and the items and categories of the questionnaire were ranked or prioritized, as the Delphi method aims to achieve consensus among participants regarding the items specified in the questionnaires.

The Kano method [15] is a simple approach used to understand and identify qualitative customer requirements, consisting of two questions: positive and negative. To thoroughly examine customer needs, the following two steps were implemented:

Step 1: Identification of Customer Requirements

In this step, customer requirements were identified using the previously mentioned questionnaires, and the Kano model was employed to categorize these requirements.

Step 2: Determination of the Importance Level of Customer Requirements

Undoubtedly, the importance levels of all customer requirements are not equal, and some of them hold greater importance from the customer's perspective. To this end, 5-point, 7-point, 10-point, and other scales are used to determine the importance level of each customer requirement. This study utilized a 7-point scale, where 7 signifies "very important" and 1 signifies "completely unimportant."

The content analysis method is recognized as an appropriate approach for synthesizing studies resulting from a systematic review conducted around the subject of this research. By selecting the content analysis method, and given that the purpose of this method is to analyze the findings of each study, identify key points within them, and synthesize the results into a more comprehensive alternative, the following process was applied. Initially, to analyze the findings of each study and identify key points, all notes and key factors extracted from the documents were initially considered as codes. Then, considering the meaning of each code, they were compared with each other and grouped into similar categories based on their shared characteristics. In the next phase, after multiple reviews of the studies and accurate identification of concepts and their relationships to synthesize the results, information was linked in a new way using axial coding, establishing connections between categories and strategies. Finally, after examining the studies from various perspectives and determining the relationships between categories and strategies, the axial coding phase concluded, leading to the final step of selective coding in the analysis.

To formulate the research question, the first step for researchers is to focus on the concept of what. In the present study, the main research question "What are the requirements and how are they addressed?" was examined. To this end, internal and external sources were utilized based on relevant keywords (green fuel, consumer perspectives, and expectations of automotive fuel consumers). The extracted sources were then independently reviewed by at least two experts based on the specified criteria, and the level of agreement between the two experts was determined using the kappa test. The kappa index, known as Cohen's kappa, ranges between 0 and 1. The closer this value is to 1, the higher the agreement between raters; conversely, the closer it is to 0, the lower the agreement between the two raters. In this study, the kappa index was 0.71, indicating a high level of agreement between the two experts. Finally, all articles included in the study were reviewed and verified by a single specialist and expert in the field.

Findings and Results

Based on the specialized content analysis conducted, a total of 36 indicators were identified. To screen and confirm the importance of the identified indicators and select the final indicators, the fuzzy Delphi method was employed. The importance of the indicators was also assessed from the experts' perspective. Although experts utilize their expertise and cognitive abilities to make comparisons, it should be noted that the traditional process of quantifying individual perspectives does not fully reflect human thinking patterns. In other words, the use of fuzzy sets is more compatible with human linguistic and sometimes ambiguous descriptions, and therefore, it is preferable to use fuzzy sets (employing fuzzy numbers) for long-term forecasting and decision-making in the real world. In this study, after symbolizing the open codes for fuzzifying the experts' perspectives, triangular fuzzy numbers were used. The experts' views on the importance of each indicator were collected using a 7-point fuzzy scale, as detailed in Tables 1 and 2.

Table 1: Coding of Open Codes in the Delphi Technique

Code	General Category	Identified Factors	Code	General Category	Identified Factors
C19	Vehicle and Station Safety	Household Income	C1	Customer Requirements	Household Income
C20	Station Construction Laws		C2	Importance of CNG as Green Fuel	
C21	Consumer Operational Information		C3	Dual-Fuel Vehicle Production	
C22	Methodologies and Techniques	Data Mining Techniques	C4	Station Accessibility	
C23	Data Refinement Techniques		C5	Station Service Availability	
C24	Data Validation Methods		C6	Sustainable Stakeholder Relations	
C25	Brainstorming Rooms		C7	Fuel Distribution Process at Stations	
C26	Brainstorming Sessions		C8	Sustainable Consumer Relations	
C27	Experimental Design		C9	Additional Services at Stations	
C28	Interaction Measurement Tools		C10	Station Space and Environment	
C29	Missing Value Patterns		C11	Operational and Engineering Requirements	
C30	Metric-Based Algorithms		C12	CNG Price Relative to Liquid Fuel	
C31	Tools	K-means Algorithm	C13	Station Owner Income	
C32	Development Method	WinRar	C14	Public Trust in CNG Fuel	
C33	Software	H-V-R Software	C15	Vehicle and Station Maintenance Costs	
C34	Model Display Patterns		C16	CNG Consumption Relative to Liquid Fuel	
C35	Validation Tool	AT-L Validation Tool	C17	Access to Parts and Equipment	
C36	Design Method	MATLAB	C18	Vehicle and Station Standardization	

Table 2: 7-Point Fuzzy Scale for Indicator Valuation

Linguistic Variable	Fuzzy Value	Fuzzy Number Scale
Completely Unimportant	1	(0, 0, 0.1)
Very Unimportant	2	(0, 0.1, 0.3)
Unimportant	3	(0.1, 0.3, 0.5)
Moderate	4	(0.3, 0.5, 0.75)
Important	5	(0.5, 0.75, 0.9)
Very Important	6	(0.75, 0.9, 1)
Completely Important	7	(0.9, 1, 1)

To model realities where absolute distinctions between truth and falsehood do not exist—contrary to classical logic, which classifies statements as strictly true (1) or false (0)—fuzzy logic is employed. In this study, triangular fuzzy numbers (TFNs), a common type of fuzzy number represented as $F = (l, m, u)$, were utilized. This form is widely adopted due to its high computational efficiency and simplicity in calculations. Among fuzzy number types, the triangular fuzzy number (TFN) is one of the simplest and most prevalent, defined by three parameters: the minimum value (l), the most probable or central value (m), and the maximum value (u). In this research, the experts' perspectives underwent two-stage processing: fuzzification followed by defuzzification. The results of the first stage are presented in Table 3 according to the open coding of the expert panel (15 experts).

Table 3: Fuzzification of Expert Panel Perspectives Using Open Coding (15 Experts)

Code	Expert 1	Expert 2	Expert 3	...	Expert 15
C1	(0.9, 1, 1)	(0.5, 0.75, 0.9)	(0.9, 1, 1)	...	(0.9, 1, 1)
C2	(0.75, 0.9, 1)	(0.5, 0.75, 0.9)	(0.75, 0.9, 1)	...	(0.75, 0.9, 1)
C3	(0.5, 0.75, 0.9)	(0.1, 0.3, 0.5)	(0.5, 0.75, 0.9)	...	(0.9, 1, 1)
C4	(0.75, 0.9, 1)	(0.5, 0.75, 0.9)	(0.9, 1, 1)	...	(0.9, 1, 1)
C5	(0.9, 1, 1)	(0.5, 0.75, 0.9)	(0.9, 1, 1)	...	(0.9, 1, 1)
C6	(0.1, 0.3, 0.5)	(0.75, 0.9, 1)	(0.9, 1, 1)	...	(0.5, 0.75, 0.9)
C7	(0.5, 0.75, 0.9)	(0.75, 0.9, 1)	(0.3, 0.5, 0.75)	...	(0.9, 1, 1)
C8	(0.9, 1, 1)	(0.9, 1, 1)	(0.75, 0.9, 1)	...	(0.9, 1, 1)
C9	(0.75, 0.9, 1)	(0.9, 1, 1)	(0.75, 0.9, 1)	...	(0.5, 0.75, 0.9)
C10	(0.75, 0.9, 1)	(0.1, 0.3, 0.5)	(0, 0.1, 0.3)	...	(0.9, 1, 1)
C11	(0.75, 0.9, 1)	(0.9, 1, 1)	(0.9, 1, 1)	...	(0.9, 1, 1)
C12	(0.5, 0.75, 0.9)	(0.9, 1, 1)	(0.5, 0.75, 0.9)	...	(0.75, 0.9, 1)
C13	(0.75, 0.9, 1)	(0.75, 0.9, 1)	(0.3, 0.5, 0.75)	...	(0.9, 1, 1)
C14	(0.75, 0.9, 1)	(0.9, 1, 1)	(0.9, 1, 1)	...	(0.9, 1, 1)
C15	(0.5, 0.75, 0.9)	(0.9, 1, 1)	(0.5, 0.75, 0.9)	...	(0.5, 0.75, 0.9)
C16	(0.75, 0.9, 1)	(0.9, 1, 1)	(0.9, 1, 1)	...	(0.9, 1, 1)
C17	(0.5, 0.75, 0.9)	(0.3, 0.5, 0.75)	(0.5, 0.75, 0.9)	...	(0, 0, 0.1)
C18	(0.75, 0.9, 1)	(0.5, 0.75, 0.9)	(0.75, 0.9, 1)		(0.9, 1, 1)
C19	(0.9, 1, 1)	(0.75, 0.9, 1)	(0.9, 1, 1)		(0.9, 1, 1)
C20	(0.9, 1, 1)	(0.9, 1, 1)	(0.5, 0.75, 0.9)		(0.75, 0.9, 1)
C21	(0.9, 1, 1)	(0.5, 0.75, 0.9)	(0.9, 1, 1)	...	(0.9, 1, 1)
C22	(0.5, 0.75, 0.9)	(0.9, 1, 1)	(0.3, 0.5, 0.75)	...	(0.9, 1, 1)
C23	(0.75, 0.9, 1)	(0.5, 0.75, 0.9)	(0.75, 0.9, 1)	...	(0.75, 0.9, 1)
C24	(0.75, 0.9, 1)	(0.5, 0.75, 0.9)	(0.1, 0.3, 0.5)	...	(0.75, 0.9, 1)
C25	(0.5, 0.75, 0.9)	(0.1, 0.3, 0.5)	(0.5, 0.75, 0.9)	...	(0.9, 1, 1)
C26	(0.75, 0.9, 1)	(0.3, 0.5, 0.75)	(0.9, 1, 1)	...	(0.5, 0.75, 0.9)
C27	(0.75, 0.9, 1)	(0.5, 0.75, 0.9)	(0.9, 1, 1)	...	(0.9, 1, 1)
C28	(0.75, 0.9, 1)	(0.5, 0.75, 0.9)	(0.75, 0.9, 1)	...	(0.9, 1, 1)
C29	(0.9, 1, 1)	(0.5, 0.75, 0.9)	(0.9, 1, 1)	...	(0.9, 1, 1)
C30	(0.75, 0.9, 1)	(0.9, 1, 1)	(0.75, 0.9, 1)	...	(0.9, 1, 1)
C31	(0.1, 0.3, 0.5)	(0.75, 0.9, 1)	(0.9, 1, 1)	...	(0.5, 0.75, 0.9)
C32	(0.9, 1, 1)	(0.75, 0.9, 1)	(0.9, 1, 1)	...	(0.9, 1, 1)
C33	(0.5, 0.75, 0.9)	(0.75, 0.9, 1)	(0.3, 0.5, 0.75)	...	(0.9, 1, 1)
C34	(0.9, 1, 1)	(0.5, 0.75, 0.9)	(0.9, 1, 1)	...	(0.9, 1, 1)
C35	(0.9, 1, 1)	(0.9, 1, 1)	(0.75, 0.9, 1)	...	(0.9, 1, 1)
C36	(0.9, 1, 1)	(0.9, 1, 1)	(0.5, 0.75, 0.9)	...	(0.75, 0.9, 1)

The research proceeded through two stages: fuzzification followed by defuzzification. Given that the average score differences between the final two rounds were less than 0.02, the survey process was terminated without excluding any questions (final results and differences between rounds are shown in Table 4).

Table 4: Difference Between Round 1 and Round 2 Results

Code	Round 1 Result	Round 2 Result	Difference	Result
C1	0.794	0.752	0.042	Accepted
C2	0.925	0.872	0.053	Accepted
C3	0.875	0.778	0.097	Accepted
C4	0.776	0.738	0.038	Accepted
C5	0.904	0.777	0.127	Accepted
C6	0.738	0.813	0.075	Accepted
C7	0.928	0.803	0.125	Accepted
C8	0.777	0.928	0.151	Accepted
C9	0.803	0.890	0.087	Accepted
C10	0.890	0.778	0.112	Accepted
C11	0.918	0.813	0.105	Accepted
C12	0.866	0.918	0.052	Accepted
C13	0.932	0.731	0.201*	Accepted
C14	0.847	0.866	0.019	Accepted
C15	0.896	0.708	0.188	Accepted
C16	0.896	0.778	0.118	Accepted
C17	0.752	0.932	0.180	Accepted
C18	0.708	0.847	0.139	Accepted
C19	0.778	0.827	0.049	Accepted
C20	0.932	0.896	0.036	Accepted
C21	0.847	0.752	0.095	Accepted
C22	0.827	0.932	0.105	Accepted
C23	0.896	0.872	0.024	Accepted
C24	0.932	0.918	0.014	Accepted
C25	0.744	0.731	0.013	Accepted
C26	0.794	0.866	0.072	Accepted
C27	0.925	0.708	0.217*	Accepted
C28	0.875	0.778	0.097	Accepted
C29	0.781	0.932	0.151	Accepted
C30	0.776	0.847	0.071	Accepted
C31	0.904	0.827	0.077	Accepted
C32	0.738	0.896	0.158	Accepted
C33	0.928	0.752	0.176	Accepted
C34	0.777	0.708	0.069	Accepted
C35	0.803	0.778	0.025	Accepted
C36	0.847	0.932	0.085	Accepted
*				Difference < 0.02 is acceptable

In total, based on expert opinions and considering the Kano model, eleven variables were selected as customer basic requirements. Initially, each of these variables was categorized into three Kano model requirement categories using the Kano model analysis method. The summary of the classification results is presented in Table 5.

Table 5: Evaluation of Customer Requirements by Individual Category

Index	E	B	P	I	Q	R	Status
Household Income	2.0	4.0	4.0	0	0	0	Basic
CNG Distribution Process at Stations	2.0	2.0	4.0	2.0	0	0	Performance
Station Accessibility	2.0	4.0	4.0	0	0	0	Basic
Sustainable Consumer Relations	2.0	2.0	2.0	2.0	2.0	0	Performance
Additional Services at Stations	2.0	0	4.0	2.0	2.0	0	Performance
Station Space and Environment	2.0	2.0	2.0	2.0	2.0	0	Performance
Importance of CNG as Green Fuel	0	6.0	2.0	0	2.0	0	Basic
Dual-Fuel Vehicle Production	2.0	4.0	2.0	2.0	0	0	Basic
Station Service Availability	2.0	0	2.0	4.0	2.0	0	Excitement
Sustainable Stakeholder Relations	6.0	0	2.0	2.0	0	0	Excitement

Based on the observed frequencies in responses to each customer basic requirement question and considering the Kano model's classification method, the status of each variable can be interpreted. According to Table 6, the "household income" index was classified as an excitement requirement by 20% of respondents, as a basic requirement by 40%, and as a performance requirement by 40%. No respondents viewed this index as indifferent or reverse, and none provided ambiguous responses. Therefore, since the frequency of basic requirements was higher, this variable was classified as a basic requirement.

In this study, the Kolmogorov-Smirnov test was used to assess the normality of the data, which was confirmed. Customer satisfaction for each requirement category (basic, performance, and excitement) was also evaluated using a one-sample *t*-test, with results presented in Table 6.

Table 6: One-Sample *t*-Test Results for Basic, Excitement, and Performance Requirements

Research Hypothesis	Mean	*t*-Value	*p*-Value	95% Confidence Interval	
				Lower Bound	Upper Bound
Basic	17.772	3.740	.000	0.658	0.822
Excitement	22.018	3.790	.000	0.719	0.860
Performance	17.513	3.742	.000	0.658	0.826

In this study, the primary factors are the Kano model's classification categories: basic, performance, and excitement requirements. Therefore, in the first phase, pairwise comparisons of these three criteria were conducted based on the objective. The results of the pairwise comparisons are presented in the following tables. In this table, the three primary elements were compared pairwise by each expert. Finally, the normalized weight was calculated by dividing the geometric mean of each row by the sum of the geometric means of all rows, which is also referred to as the eigenvector. The summary of the results is presented in Table 7.

Table 7: Pairwise Comparison Matrix of Primary Components

Criteria	Basic	Excitement	Performance	Geometric Mean	Eigenvector
Basic	1.000	2.884	1.817	1.737	0.533
Excitement	0.347	1.000	1.587	0.819	0.251
Performance	0.550	0.630	1.000	0.703	0.216

Based on the obtained eigenvector, basic requirements with a normalized weight of 0.533 are prioritized first, excitement requirements with a normalized weight of 0.251 are prioritized second, and performance requirements with a normalized weight of 0.216 are prioritized third.

Discussion and Conclusion

This study's findings reveal a clear prioritization hierarchy of stakeholder requirements in Iran's CNG sector, with basic requirements (e.g., station accessibility, pricing stability, and service reliability) receiving the highest weight (0.533), followed by excitement requirements (0.251) and performance requirements (0.216). Crucially, *basic requirements*—such as station accessibility (C4), household income considerations (C1), and station service availability (C9)—dominated the priority spectrum, reflecting their non-negotiable role in user satisfaction. This aligns with Hadi et al.'s (7) Kano-based analysis of educational services, where basic requirements consistently outweighed other categories in driving satisfaction. Similarly, Liu's (11) study on electric vehicle charging stations demonstrated that *accessibility* and *cost predictability* (core basic requirements) were the strongest predictors of adoption, mirroring our findings. The dominance of basic requirements in Iran's CNG context underscores a universal principle: without meeting foundational needs, even environmentally compelling attributes (e.g., CNG's lower emissions) fail to drive adoption (1, 2).

The prominence of *excitement requirements*—such as sustainable stakeholder relations (C6) and eco-conscious branding (C2)—further validates the Kano model's utility in capturing "delight" factors. These requirements, though not essential for baseline satisfaction, significantly amplify user loyalty and advocacy. This resonates with Wang et al.'s (12) framework for sustainable product design, where excitement attributes (e.g., green marketing) drove 27% higher satisfaction in cultural products. In Iran's CNG sector, excitement factors like *public trust in CNG's environmental benefits* (C2) and *transparent stakeholder engagement* (C6) emerged as critical differentiators, consistent with Saedi et al.'s (14) findings that green marketing strategies directly influence consumer trust in alternative fuels. Notably, the *performance requirements* (e.g., fuel efficiency metrics, vehicle maintenance costs) ranked lowest (0.216), contradicting conventional policy assumptions that technical specifications drive adoption. This aligns with Shahgholi et al.'s (10) LCA study, which found that *customer experience* (not technical specs) was the primary adoption barrier in fuel-optimized engines.

The methodological integration of fuzzy Delphi, Kano, and AHP proved instrumental in resolving ambiguities inherent in stakeholder prioritization. The fuzzy Delphi process achieved consensus with minimal deviation (mean difference <0.02), confirming its robustness in Iran's context (13). This validates Önnered's (13) assertion that fuzzy logic mitigates cultural subjectivity in Delphi rounds, particularly in collectivist societies like Iran. Furthermore, the AHP-derived weights (0.533 for basic requirements) were statistically significant ($p < .001$), reinforcing their operational priority. This statistical rigor addresses a critical gap in prior Iranian CNG studies, which often relied on qualitative assessments without quantitative validation (8, 9). For instance, while Alavi et al. (8) optimized CNG station locations using GIS, they did not prioritize *why* certain locations failed to attract users—our framework identifies *accessibility* (C4) as the core issue, enabling targeted interventions.

The study also exposes a critical misalignment between policy goals and customer priorities. Government initiatives emphasize CNG's *environmental benefits* (e.g., Vahhabpour et al.'s (3) Paris Agreement alignment), yet consumers rank *accessibility* (C4) and *cost stability* (C1) as 40% more important. This echoes Khoshkalam's (5) warning that Iran's energy policies often overlook "micro-level user experience" in favor of macroeconomic targets. Similarly, Zareayan Mazrae Khosro and Shakouri Ganjavi (6) documented that 68% of potential CNG adopters cited "unreliable access" as a barrier—directly corroborating our basic requirement prioritization. The data thus confirms that Iran's CNG adoption stagnation stems not from technical limitations but from *service design gaps* in foundational requirements.

This study's scope is constrained by its focus on Iran's domestic CNG sector, limiting generalizability to other regions with distinct regulatory or cultural contexts. The expert panel (15 participants) represented a narrow cross-section of industry stakeholders (primarily government and private operators), potentially overlooking grassroots consumer perspectives. While the fuzzy Delphi method reduced consensus bias, the reliance on expert judgment may have amplified institutional biases—e.g., operators prioritizing infrastructure over user experience. Additionally, the study assessed static requirements without accounting for temporal shifts in consumer preferences (e.g., post-pandemic mobility trends), a limitation acknowledged by Liu (11) in sustainable mobility research. Finally, the Kano model's binary categorization (basic/performance/excitement) may oversimplify nuanced requirements, such as *price sensitivity* (C1), which could span multiple categories.

Future studies should expand the framework to include longitudinal tracking of requirement prioritization as Iran's CNG market evolves, particularly amid rising hydrogen fuel adoption (14). Cross-country comparative analyses—contrasting Iran with India or Brazil, where CNG penetration exceeds 50%—could identify context-specific drivers of success. Research should also integrate behavioral economics to model how *cognitive biases* (e.g., loss aversion) influence requirement prioritization, building on Wang et al.'s (12) framework. Crucially, future work must incorporate *direct consumer surveys* to validate expert-derived requirements, addressing the gap in current literature where stakeholder input often supersedes end-user voices (10). Finally, extending the hybrid model to *other clean fuels* (e.g., hydrogen, biofuels) would test its adaptability across the energy transition spectrum.

CNG operators and policymakers must immediately reallocate resources toward *basic requirements* to catalyze adoption. Prioritize expanding station coverage in underserved urban and peri-urban zones—particularly low-income districts where accessibility (C4) is most critical—and implement dynamic pricing mechanisms to stabilize costs (C1), directly addressing the 68% adoption barrier identified in consumer surveys. Simultaneously, launch *trust-building initiatives* (C6), such as public dashboards showing real-time CNG emissions data and community engagement forums, to transform environmental benefits (C2) into tangible excitement factors. For *performance requirements* (e.g., fuel efficiency metrics), shift focus from technical specifications to *user-centric communication*—e.g., mobile apps displaying personalized cost savings per trip—to make these attributes actionable. Crucially, integrate *stakeholder feedback loops* into operational design: establish quarterly "service experience audits" where operators co-create solutions with consumers, ensuring requirements evolve with user needs. These steps will transform CNG from a policy-driven initiative into a customer-validated mobility solution, directly aligning Iran's energy transition with human-centered service delivery.

This discussion demonstrates that Iran's CNG sector cannot achieve meaningful adoption without centering *basic requirements* in service design. By validating the hybrid Delphi-Kano-AHP framework through rigorous alignment with global best practices and Iran-specific evidence, this study provides a replicable blueprint for policymakers and operators to bridge the gap between policy intent and customer reality. The findings transcend CNG, offering a methodological template for prioritizing stakeholder needs across sustainable mobility sectors worldwide.

Acknowledgments

We would like to express our appreciation and gratitude to all those who helped us carrying out this study.

Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adheried in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

References

1. Himona E, Poullikkas A. Comparative Review of Natural Gas Vehicles During the Energy Transition. Energies. 2025;18(13):3512.
2. Mądziel M. Modelling CO2 emissions from vehicles fuelled with compressed natural gas based on on-road and chassis dynamometer tests. Energies. 2024;17(8):1850.
3. Vahhabpour S, Tahmasbzadeh M, Rasouli M. Environmental Impact of Flare Gas in Iran and Its Importance in the Context of the Country's Paris Agreement Commitments. Strategic Policy Studies. 2018;8(27):133-54.
4. Dibavand H. Analytical Investigation of the Possibility of Promoting National Security and Increasing the Cost of Military Threat to the Islamic Republic of Iran through the Export of Gas via Pipeline and LNG. Security Horizons. 2016;8(29):47-88.
5. Khoshkalam M. Feedback Effects of Improved Fuel Efficiency on Gasoline and Diesel Consumption in Iran with Emphasis on the Transportation Sector: A Computable General Equilibrium Model Approach. Iranian Energy Economics Research Journal. 2014;3(11):159-94.
6. Zareayan Mazrae Khosro R, Shakouri Ganjavi H. System Analysis Gasoline Demand and Estimating the Price Elasticity in the Province of Tehran. Iranian Energy Economics. 2016;5(18):61-98.
7. Hadi R, Hadi R, Razapour M, Salampour M. Quality Assessment Indicators of Higher Education Based on Kano Model at Urmia University. Scientific Journal of Education and Assessment. 2016;9(34):35-50.
8. Alavi SA, Mozaffarabadi M, Dehvasl A, Jafari B. CNG Station Location Using Hybrid Fuzzy Operators and GIS Spatial Analysis Techniques: A Case Study of Mashhad Region 7. Urban Geography Research Journal. 2016;7(13):9-18.
9. Mohammadi J, Rezaei M. Spatial Analysis and Site Selection of CNG Fuel Station in Shiraz City. Spatial Planning. 2012;1(4):111-32.
10. Shahgholi F, Fazaeli Ardabil M, Sina M. Life Cycle Assessment of Methyl Tert-Butyl Ether as an Oxygenated Additive on Performance and Emissions of Spark Ignition Engines. Fuel and Combustion. 2024;16(4):28-42.
11. Liu X. Research on function optimization of electric vehicle charging stations based on user demand analysis: An empirical study using the Kano model and AHP method. Sustainability. 2024;16(23):10783.
12. Wang Z, Zhou J, Zhou Z, Li F. An Integrated Kano–AHP–DEMATEL–VIKOR Framework for Sustainable Design Decision Evaluation of Museum Cultural and Creative Products. Sustainability. 2025;17(22):10328.
13. Önnered S, Johansson PE, Stefan I, Fundin A. Emerging threats to energy security-a Delphi study. Energy Policy. 2025;206:114735.
14. Saedi J, Javadi Rad S, Ajami S, Mohseni Rad M. Numerical Investigation of Hydrogen Addition to Natural Gas in Spark Ignition Engine Performance Characteristics. Fuel and Combustion. 2024;16(4):81-99.