

CONSUMER ACCEPTANCE OF COMPRESSED NATURAL GAS: A BEHAVIORAL PERSPECTIVE

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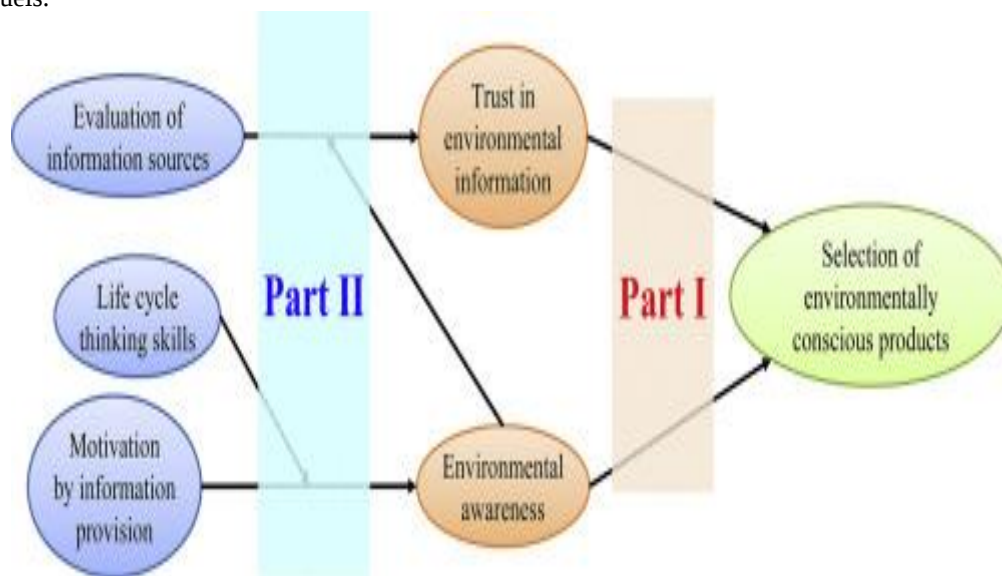
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Abstract- Compressed Natural Gas (CNG) has developed as a viable alternative fuel in the transportation industry, providing environmental and economic benefits compared to traditional fossil fuels. Notwithstanding its advantages, the rate of consumer acceptance and implementation differs markedly among areas and demographic groupings. This study seeks to examine the principal factors affecting consumer adoption of CNG as a favoured transportation fuel. The research is motivated by the growing global demand for a transition to sustainable and low-emission energy sources, especially in metropolitan areas where vehicle emissions significantly contribute to air pollution. Initial studies indicate that environmental concern, cost-effectiveness, fuel availability, and perceived performance are essential factors influencing adoption, whereas obstacles comprise inadequate refuelling infrastructure, insufficient awareness, and apprehensions about vehicle performance. Moreover, governmental activities including subsidies, tax incentives, and awareness initiatives significantly influence consumer perception. This study enhances the existing information on sustainable transportation by elucidating the many aspects influencing consumer choices related to alternative fuels. The results can aid politicians, automotive manufacturers, and energy firms in formulating specific strategies to expedite the adoption of CNG.

Keywords: Compressed Natural Gas (CNG), consumer behavior, alternative fuel, sustainable transportation, fuel adoption, green mobility, environmental perception, infrastructure and policy impact.

1. INTRODUCTION

The escalating apprehensions over climate change, environmental deterioration, and the exhaustion of fossil fuel reserves have compelled the international community to pursue cleaner and more sustainable energy options. Compressed Natural Gas (CNG) has attracted great interest for its capacity to substantially decrease automotive emissions while providing economic benefits to customers. CNG, with a reduced carbon content relative to petrol or diesel, generates less emissions, including carbon monoxide, nitrogen oxides, and particulate matter. Moreover, nations with substantial natural gas supplies might utilise CNG as a strategic instrument to diminish reliance on imported fuels.



Notwithstanding its evident advantages, the integration of CNG as a predominant transportation fuel is inconsistent, and comprehending the determinants of customer acceptability is a critical issue for stakeholders in the energy and transportation industries. Environmental awareness is a significant factor affecting customer acceptance of CNG. As

awareness of climate change and air pollution increases, customers are progressively favouring environmentally sustainable options. Individuals that emphasise environmental conservation are more inclined to explore alternate fuels, such as CNG. Nonetheless, degrees of awareness differ significantly according to education, geographic location, and availability of information. Consequently, educational and promotional initiatives may significantly influence customer perceptions and enhance the perceived value of CNG. Economic issues substantially influence consumer decision-making. The economic superiority of CNG compared to petrol and diesel—attributable to reduced fuel prices and maintenance expenses—renders it a compelling choice. The initial expense of acquiring a CNG car or retrofitting an existing one may serve as a deterrent. Government incentives, like subsidies, tax refunds, and low-interest financing choices, can alleviate these fears and promote wider use.

2. CONTEXT OF THE RESEARCH

A vital factor is the accessibility of infrastructure, especially refuelling stations. An established CNG distribution network fosters consumer trust and mitigates "range anxiety." In areas where CNG stations are limited or inconveniently situated, consumers may be reluctant to adopt the fuel, despite its advantages. Consequently, infrastructure development is vital and necessitates collaborative efforts between governmental authorities and private firms. Perceptions of performance also influence customer acceptability. A common misunderstanding is that CNG cars possess worse power or reliability compared to conventional gasoline vehicles. Despite substantial enhancements in the performance of CNG engines due to technological developments, persistent uncertainties may dissuade prospective consumers. Demonstrations, test drives, and user testimonials can successfully mitigate such worries and enhance public impression. Social influence and peer behaviour also impact fuel selection. When customers witness family, friends, or community members embracing CNG vehicles, they are more inclined to contemplate doing so themselves. Word-of-mouth, social validation, and regional patterns significantly influence adoption and dissemination. In this environment, early adopters and influencers are pivotal in promoting widespread adoption. Policy and regulatory frameworks significantly influence consumer behaviour. Stringent pollution regulations, congestion pricing, and incentives for low-emission cars foster an atmosphere conducive to the adoption of cleaner fuels. Conversely, erratic policy execution or ambiguity may result in customer reluctance. A robust and supportive regulatory framework is therefore crucial to foster consumer confidence and sustained engagement. Moreover, technical developments and innovations might augment the appeal of CNG. Contemporary CNG engines provide enhanced fuel efficiency, superior safety attributes, and a more seamless driving experience. As automotive manufacturers allocate resources to research and development, the market may anticipate enhanced performance and more visually appealing CNG cars, perhaps attracting a wider consumer demographic. Ultimately, customer awareness and trust are essential. Disinformation, fallacies, or insufficient access to accurate information might impede adoption. Clear communication, consumer education, and trust-building initiatives are essential for alleviating scepticism and cultivating a favourable perception of CNG.

3. LITERATURE REVIEW AND RESEARCH AGENDA

Sadickuzzaman and Shuvo (2024) investigated customer perceptions on the adoption of sustainable CNG-based transportation in Chittagong, Bangladesh. The study evaluates the impact of consumer perceptions on the public acceptance of CNG as an eco-friendly alternative due to escalating environmental concerns and the imperative to reduce carbon emissions. This study conducts a statistical analysis of survey data obtained from commuters, vehicle owners, and transport operators in Chittagong. Three primary factors influencing customer perceptions of alternative fuels are cost-effectiveness, environmental benefits, and vehicle performance efficiency. Research indicates that consumers see compressed natural gas favourably due to its practical applications and environmental advantages, especially in public transit and personal automobiles. The further use of CNG encounters obstacles due to limited refuelling facilities, inconsistent natural gas supply, and challenges in maintaining converted cars. The study employs governmental incentives alongside enhanced infrastructure networks and public awareness initiatives to promote sustainable CNG uptake. The authors advocate for collaboration between government officials and transport authorities to provide additional refuelling stations, ensure consistent petrol supplies and provide financial support for vehicle upgrades. Augmenting customer trust via these initiatives would facilitate the advancement of Chittagong's metropolitan area towards sustainable transportation.

Saraf and Shastri (2024) analyzed customer preferences as catalysts for decarbonization within India's transport industry. The authors elucidate how consumer behaviour influences the adoption of low-emission vehicles and sustainable transportation solutions against the backdrop of India's initiative to diminish greenhouse gas emissions. A mixed methods research strategy integrates surveys with statistical modelling to assess consumer preferences for electric cars (EVs), hydrogen fuel cell vehicles (HFCVs), and CNG-based transportation networks. The study found that customers prioritize cost savings while prioritizing environmental protection and improved fuel efficiency when

embracing sustainable transportation options. The primary obstacles hindering electric car adoption include limited driving range, inadequate charging infrastructure, and elevated initial costs. The research indicates that investments in consumer outreach and improved charging infrastructure, together with more education about the advantages of these cars, will facilitate greater adoption. The authors advocate for the establishment of a sustainable transportation ecosystem via policy coordination among three stakeholder groups: politicians and their partners, automakers, and environmental authorities. This research illustrates how aligning consumer requirements with cleaner energy programs increases India's likelihood of effectively achieving its environmental objectives.

4. RESEARCH GAP

Notwithstanding the growing global focus on clean energy and sustainable mobility, current research on consumer acceptability of compressed natural gas (CNG) is constrained in both breadth and contextual relevance. Numerous studies have predominantly concentrated on the technical and environmental benefits of CNG, frequently neglecting the behavioral, psychological, and socio-economic factors that affect consumer choices. Although several studies have investigated adoption patterns in wealthy nations, there is a deficiency of thorough study focusing on emerging markets and developing countries, where infrastructural obstacles, legislative structures, and cultural perspectives vary considerably. Moreover, scant research incorporates interdisciplinary viewpoints—such as marketing, environmental psychology, and behavioural economics—to comprehensively analyze customer behaviour regarding CNG automobiles. A further vacuum exists in longitudinal studies that evaluate how temporal changes in legislation, fuel prices, or public knowledge influence consumer attitudes and adoption rates. Furthermore, the impact of digital influence, peer perception, and risk tolerance on influencing acceptance has been inadequately examined. Consequently, a comprehensive examination of these under-explored domains is important to formulate customised strategies for enhancing CNG uptake. Addressing these deficiencies would enhance comprehension of the intricacies related to fuel selection behaviour and yield practical insights for policymakers, manufacturers, and urban planners pursuing sustainable mobility solutions.

5. SIGNIFICANCE OF THE RESEARCH

The work is crucial for worldwide initiatives aimed at reducing greenhouse gas emissions, addressing urban air pollution, and advancing sustainable transportation methods. As nations endeavor to shift from fossil fuels to greener alternatives, comprehending consumer acceptability of Compressed Natural Gas (CNG) is essential for successful policy development and execution. CNG offers a practical alternative that merges ecological advantages with economic viability, especially for nations possessing indigenous natural gas deposits. Nonetheless, in the absence of market acceptance, even the most promising fuel technologies are susceptible to underutilization. This study elucidates the behavioural and environmental determinants affecting CNG adoption, therefore reconciling the disparity between technological promise and practical implementation. Insights from this research will assist stakeholders—such as government agencies, car manufacturers, and energy providers—design better focused actions, from infrastructure expenditures to public awareness campaigns. Moreover, the study corresponds with sustainable development goals (SDGs), namely those pertaining to clean energy, climate action, and sustainable urban development. This research prioritizes consumer behaviour, transitioning the emphasis from supply-side solutions to demand-side concerns, so fostering a more equitable and human-centered approach to environmental policy and innovation within the transportation industry. The study ultimately endorses the overarching objective of attaining cleaner, healthier, and more sustainable urban settings.

6. RESEARCH PROBLEM

The transportation industry significantly contributes to environmental pollution and greenhouse gas emissions, necessitating global initiatives to advance cleaner and more sustainable fuel choices. Compressed Natural Gas (CNG) has become a viable alternative owing to its reduced carbon emissions, economic efficiency, and relative availability. Nonetheless, despite its ecological and financial benefits, the extensive consumer acceptance of CNG vehicles is still constrained in several areas. This gap presents a significant question: what hinders customers from adopting an apparently superior fuel alternative? The issue is not alone in the accessibility of CNG infrastructure but also in the intricate interaction of psychological, economic, societal, and policy-related elements that affect customer behaviour. Numerous prospective users are oblivious to the advantages of CNG or are deterred by perceived obstacles, including a scarcity of refuelling stations, elevated initial expenses, misunderstandings regarding performance, and safety apprehensions. Moreover, the erratic execution of governmental programs, insufficient promotional initiatives, and absence of specific incentives has exacerbated consumer decision-making. The absence of thorough, interdisciplinary research that addresses both tangible and intangible factors influencing customer acceptability intensifies this issue. As a result, the disparity between governmental aims and consumer behaviour endures. Comprehending the

fundamental reasons for the inadequate acceptability of CNG is thus crucial. In the absence of this knowledge, plans to advance green transportation will be ineffectual, hindering progress towards environmental sustainability and energy security objectives.

7. OBJECTIVES OF THE STUDY

The objectives of this study are threefold: (1) to identify the socio-demographic and psychological variables that influence consumer attitudes toward CNG vehicles, (2) to evaluate the impact of infrastructure availability, government policy, and economic incentives on consumer behavior, and (3) to propose strategic recommendations to enhance the adoption of CNG in the transportation sector. The research employs a mixed-methods approach, including a comprehensive review of existing literature, surveys, and expert interviews to derive insights.

8. FINDINGS AND RESULTS

The acceptance of Compressed Natural Gas as a transportation fuel is influenced by a complex interplay of environmental, economic, infrastructural, psychological, social, and regulatory factors. To promote widespread adoption, it is essential to address these multifaceted concerns through a coordinated approach involving policymakers, industry players, and civil society. By understanding and acting upon these influencing factors, stakeholders can accelerate the transition toward a cleaner and more sustainable transportation future.

Table-8.1 Factors Influencing Consumer Acceptance of (CNG)

S. No.	Factors	Mean	Std. Dev	Mean Rank
1.	Environmental Awareness	2.44	1.209	7.17
2.	Fuel Cost and Economic Benefits	2.00	.977	6.20
3.	Vehicle Performance Perception	2.13	1.097	6.31
4.	Safety Concerns	2.23	1.467	6.63
5.	Availability of Refueling Infrastructure	2.53	1.372	7.69
6.	Government Policies and Incentives	2.19	1.268	6.58
7.	Social Influence and Peer Perception	2.79	1.497	7.64
8.	Brand Trust and Manufacturer Support	2.14	1.155	6.37
9.	Technological Familiarity and Knowledge	2.84	1.037	8.57
10.	Maintenance Cost and Service Availability	2.45	1.392	7.32
11.	Media and Marketing Influence	2.27	1.169	6.81
12.	Convenience and Ease of Use	2.19	1.034	6.95
13.	Risk Aversion and Uncertainty	2.13	1.040	6.78

The analysis of the mean scores and mean ranks of various factors influencing consumer acceptance of Compressed Natural Gas (CNG) reveals insightful patterns. The factor with the highest mean rank is Technological Familiarity and Knowledge (Mean = 2.84; Mean Rank = 8.57), indicating that consumers' lack of technical understanding or awareness about CNG technology is a major barrier to its acceptance. Closely following are Social Influence and Peer Perception (Mean = 2.79; Mean Rank = 7.64) and Availability of Refueling Infrastructure (Mean = 2.53; Mean Rank = 7.69), suggesting that societal perceptions and limited fueling accessibility significantly affect consumer decisions. Fuel Cost and Economic Benefits (Mean = 2.00; Mean Rank = 6.20) received one of the lowest mean scores and ranks, highlighting that cost-effectiveness is a motivating factor that positively influences acceptance. Vehicle Performance Perception and Risk Aversion and Uncertainty also scored relatively low, indicating that these are less significant barriers compared to others. Interestingly, Environmental Awareness and Maintenance Cost and Service Availability had moderate mean scores but relatively higher mean ranks, reflecting some level of consumer concern toward environmental impact and long-term upkeep. Overall, the findings suggest that knowledge gaps, infrastructure limitations, and social perceptions are more pressing concerns than economic factors. These insights can inform targeted interventions such as public education campaigns, improved CNG infrastructure, and community-based awareness programs to enhance consumer acceptance of CNG as a sustainable fuel option.

9. DISCUSSION

Harichandan and Kar (2023) illustrated that hydrogen fuel cell vehicles (HFCVs) serve as a sustainable energy option that tackles global environmental challenges and handles difficulties within the Indian automotive sector. The study employed an empirical research approach utilising structured questionnaires to collect data from consumers in major Indian metropolitan centres. Consumer perception is influenced by three primary factors: environmental awareness, economic benefits, and safety considerations. The study respondents perceived hydrogen fuel cell vehicles (HFCVs) as ecologically advantageous but remained hesitant to adopt the technology due to elevated prices, limited refuelling infrastructure, and prevailing safety concerns. The authors emphasise that the effectiveness of HFCVs relies on deliberate governmental measures. The authors advocate governmental fuel subsidies, tax incentives, and investments in hydrogen station infrastructure to stimulate consumer interest. India's robust hydrogen infrastructure necessitates ongoing collaboration among automotive manufacturers, energy firms, and governmental agencies. The study demonstrates that mitigating these constraining factors will significantly enhance consumer receptiveness, hence fostering sustained mobility progress in India. Paul and Sharma (2023) examined Indian consumers' perspectives on the utilisation of Compressed Natural Gas (CNG) and Piped Natural Gas (PNG). The inquiry examines consumer demands for greener energy methods by assessing relevant aspects that shape their perceptions. The authors employ a standardised survey to gather responses from PNG and CNG consumers residing in urban and semi-urban regions. The research indicates that CNG meets customer needs by offering cost-effective operating and environmental advantages for vehicles. PNG is acknowledged by customers for its suitability as a domestic fuel, offering dependability and user-friendliness. The research identified significant challenges while acknowledging the advantages of CNG and PNG, including insufficient infrastructure, safety hazards, and supply chain inconsistencies. The authors propose the implementation of targeted awareness programs that demonstrate how natural gas offers both economic advantages and environmental benefits. The authors emphasise that customer trust relies on enhanced infrastructure and improved safety protocols for the implementation of CNG and PNG systems. India needs collaborative efforts among policymakers, energy suppliers, and municipal authorities to expedite the adoption of CNG and PNG.

10. IMPLICATIONS OF THE STUDY

The results of this investigation include considerable theoretical, practical, and policy consequences. This research enhances the existing literature on sustainable consumer behaviour by identifying and analyzing the multifaceted elements that influence the adoption of alternative fuels, including CNG. The study improves current consumer decision-making models on green transportation systems by integrating behavioural, socio-economic, and infrastructural aspects. The survey offers significant insights for automotive manufacturers, energy providers, and service stations on consumer preferences, concerns, and motivations. These insights can guide the formulation of enhanced marketing strategies, product developments, and service delivery methods customised to customer wants and perceptions. The paper provides evidence-based suggestions for policymakers to enhance the adoption rate of CNG cars via targeted subsidies, enhanced infrastructure, public awareness initiatives, and regulatory frameworks that promote cleaner energy utilization. It also underlines the significance of integrating national sustainability goals with grassroots-level consumer behavior. Moreover, the study can assist urban planners and transportation authorities in developing sustainable urban models by integrating cleaner fuel choices into public and private transportation networks. The research endorses global programs such as the United Nations Sustainable Development Goals (SDGs), especially those pertaining to renewable energy, sustainable urban development, and climate action. The research functions as a strategic instrument for promoting the use of CNG and expediting the worldwide shift towards low-carbon, environmentally sustainable transportation options.

11. RECOMMENDATIONS AND SUGGESTIONS

This study's findings yield numerous specific recommendations to improve customer acceptability of Compressed Natural Gas (CNG). Initially, awareness initiatives must be enhanced to inform the people about the environmental and economic advantages of CNG. Given that technical familiarity and expertise are the most significant influencing elements, governmental and corporate entities should initiate informative outreach campaigns, potentially in partnership with educational institutions and media organisations. Furthermore, the augmentation of CNG refuelling infrastructure is crucial to enhance accessibility and convenience for consumers, particularly in semi-urban and rural regions. Public-private collaborations can be pivotal in realising this objective. Manufacturers should prioritise investment in product innovation to mitigate issues related to vehicle performance and maintenance. Offering warranties, servicing incentives, and post-sale assistance may enhance brand credibility. Furthermore, policy-level actions, such as tax exemptions, fuel subsidies, and car registration reductions, can act as significant incentives. Finally, leveraging social influence via community leaders, influencers, and early adopters can favourably alter public image.

Collectively, these efforts may cultivate a more educated and supportive atmosphere that aids the shift to cleaner, more sustainable transportation alternatives.

CONCLUSION

The shift to ecologically friendly transportation systems is an urgent worldwide need, and Compressed Natural Gas (CNG) serves as a feasible alternative in this context. Nonetheless, customer approval is crucial in ascertaining the effectiveness of CNG uptake. This study examined the many elements affecting customer decisions and found that although economic advantages are typically acknowledged; substantial obstacles are embedded in consumer behaviour and perception. Technological unfamiliarity, insufficient infrastructure, and societal influence surfaced as the primary obstacles preventing customers from transitioning to CNG. These findings underscore that although the technology exists, the primary problem is closing the gap in awareness and trust between customers and the product. The study underscores the necessity of a comprehensive approach that not only advocates for the advantages of CNG but also proactively tackles consumer apprehensions. Relying just on environmental or economic considerations is insufficient; buyers must possess confidence in the performance, safety, and long-term sustainability of CNG cars. The significance of government policy, market incentives, and community involvement is paramount in altering views and promoting behavioral change. In conclusion, enhancing the adoption of CNG necessitates synchronised efforts across several sectors. Public education, infrastructural enhancement, technology trust-building, and the formulation of appropriate legislative procedures are essential for fostering sustained adoption. If these areas are effectively handled, CNG can function as an effective transitional fuel in the worldwide shift towards cleaner energy and diminished carbon emissions. Ultimately, consumer acceptability is not only a behavioural concern but a fundamental element for realising extensive environmental objectives in the transportation industry.

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