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RESEARCH ARTICLE

Factors affecting perception of generation z and generation alpha towards purchase of automobile variants: An environmental perspective

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ABSTRACT

The automotive sector is undergoing a transformative period, marked by technological advancements, sustainability imperatives, and economic uncertainties. The present paper explores the intricate interplay between the choice of automobile, preference factors, and generational perspectives. This paper explores Generation Alpha's (born 2010 onward) approach to the evolving automotive landscape, focusing on their vehicle preferences and perspectives on environmental concerns. The paper examines the concept of sustainability, Industry 5.0, government policies, the role of stakeholders in promoting environmental sustainability, state and sectoral advancements, the influence of technology on vehicle adoption, factors influencing buyer behavior, and the challenges to adopting various types of vehicles. The paper's findings highlight the evolving nature of consumer preferences and the factors affecting purchase intent. It emphasizes the growing adoption of hybrid and environmentally friendly vehicles, driven by supportive government policies and their global impact. The study underlines that flexibility and subsidies for purchasing hybrid and environmentally friendly vehicles will drive transformative changes in the automobile industry soon. It also underscores the importance of innovative branding and marketing strategies to raise awareness and promote conscious decision-making in vehicle purchases and thereby drive sustainable transformation in the global automobile industry worldwide.

Keywords: automotive sector; environmental sustainability; generation z; vehicle variant; generation alpha; automation, purchase intention; SDG 12.8 (Ensuring awareness for sustainable style); SDG 13.2 (Integrating climate action into policy)

1. Introduction

The concept of transforming transportation choices from the ecological point of view has been the latest

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trend by the world's government and reduction in carbon emissions requires the transition to new kinds of transport system[1]. Understanding the environment is now crucial for the new generations to adopt a sustainable method of lifestyle. As newer generations become more aware and eco-friendlier, their approach towards choices of purchase has become more ecological than economical as compared to the previous generations[2]. Even though sustainable mobility is in its growing stage, the purchasing choices of Generation Z show prominent changes in the automotive market. The automotive industry is one of the major driver affecting the economic growth of the country. The nation's automakers provide vehicles that specifically meet the needs of lower- and middle-class consumers[3]

The comparative analysis of global automotive sectors reveals significant insights into competitiveness and industry dynamics. China, the USA, Japan, and Germany emerged as the largest car producers, with Germany, Japan, and Canada being top exporters[4]. Norway has actively promoted electric vehicles (EVs), achieving a market share of 79.3%. This growth has been driven by substantial support measures, including subsidies, tax rebates, exemptions from congestion fees, and road toll waivers, all aimed at encouraging EV adoption and fostering positive consumer behaviour toward sustainable transportation.

This research understands the purchase choice of Generation Z concerning millennials, keeping in mind, the challenges faced due to a lack of understanding of consumer attitudes and purchase intentions toward sustainable transport[5].

1.1. Sustainability in the automotive industry?

The automobile industry is a strong driver when it comes to upcoming sectors for growth and development which supports global chains largely. With enormous changes happening all over the world, there has been a large and integrated development in the industrial sector. It affects GDP, and employment and also affects FDI inflows. India is the sixth largest producer in the automobile industry, deploys a huge workforce of around 29 million vehicles, the second largest two-wheeler manufacturer, and the eighth largest commercial vehicle manufacturer. The Indian industry accounted for almost 5% of vehicle production in commercial value. This has also made India one of the most attractive destinations for multinational automobile companies with business expansion prospects and has also attracted 14.48 Billion Dollars in the last decade.

Sustainability in the automotive industry involves a holistic view of various planet and human-friendly operations, processes, products and services[6].

The change in dynamics of the approach towards newer ecological policies particularly in the context of the automotive sector can be attributed to a confluence of factors. The International Solar Alliance (ISA) which was launched in 2015 and the Paris Agreement held in 2015 are symbolic of global efforts to address climate change and transition towards sustainable practices[7]. When examining the automotive sector, especially in India, these global initiatives, along with domestic policies and changing generational perspectives, play a pivotal role in shaping the industry's trajectory[8].

The Paris Agreement and initiatives like the ISA underscore the global commitment to mitigating climate change. The automotive sector, being a significant contributor to greenhouse gas emissions, is under increasing pressure to align with these international commitments[9].

The Union Budget 2023-2024 in India reflects a strong emphasis on "Green Growth" and sustainable mobility. Financial allocations, incentives, and policy measures geared towards promoting electric vehicles (EVs), green fuel, and green mobility signal a shift in government priorities**.**

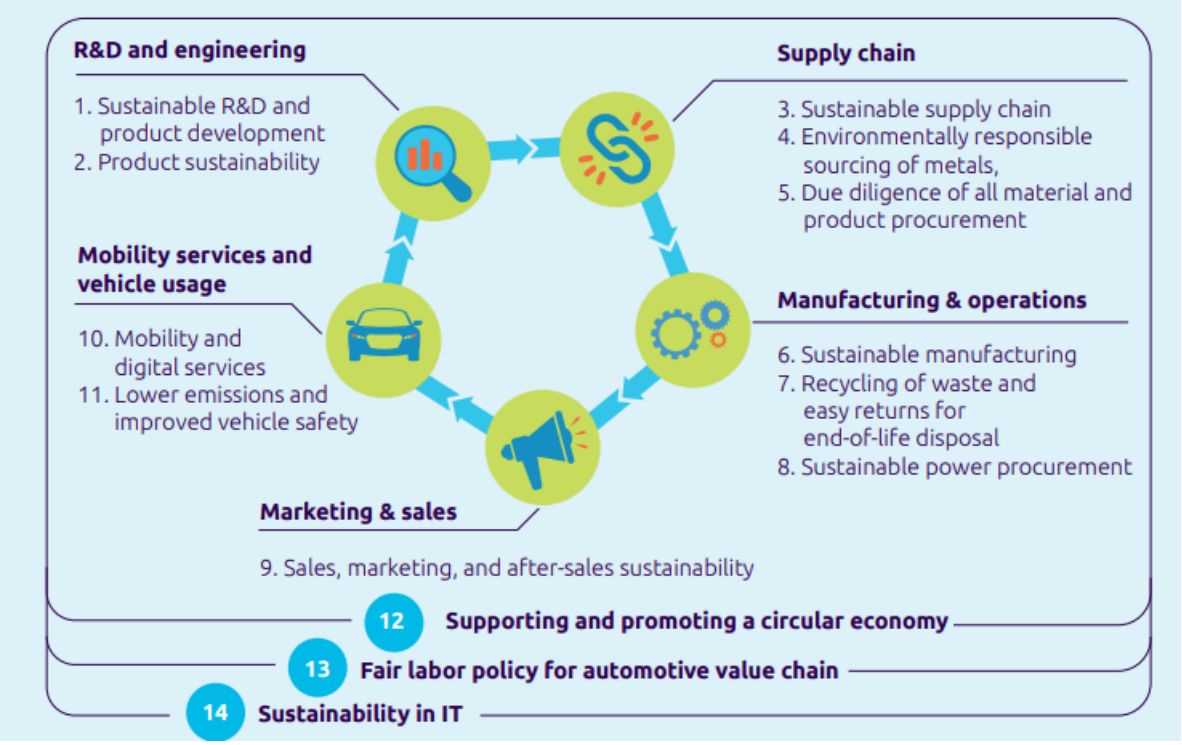

Figure 1. Sustainability across automotive value-chain.

Source: *Capgemini Institute "Report-The-Automotive-Industry-in-the-Era-of-Sustainability" 2020.*

Automobile manufacturers face significant pressure to adapt vehicle features, not only to meet customer preferences but also to comply with government policies, regulations, and technical guidelines. Sustainability in the automotive industry encompasses building strong branding, achieving global efficiency, and focusing on emission reduction, lightweight vehicle construction, enhanced connectivity, and mobile services. The goal is to develop models that are green, clean, economical, socially and ecologically viable, and efficient[10].

The implementation of sustainability practices varies across industries and service types, ranging from the use of natural fibers and biological composites to incorporating sustainable materials in vehicle interiors. These measures align with the broader objectives of ecological and social responsibility within the sector.

On the financial side the incentives as demonstrated by the Indian government's budget, play a crucial role in steering consumer choices. Incentives for EV manufacturing, subsidies, and exemptions contribute to making sustainable options economically viable for consumers. Such incentives make the transition much easier for Gen Z.

The data analysis section demonstrates a shift in market dynamics, with a decline in diesel vehicle purchases and an increasing interest in electric and hybrid vehicles. Consumer preferences are evolving, influenced by environmental awareness and changing economic landscapes.

1.2. Sustainability initiatives in the automotive sector: Government Policy Intervention

Going further let us look at the types of policies and changes that are introduced by the government in this particular sector:

The following paragraph explains the policy changes in the automotive sectors:

- 1972 - The time when the world felt a need for environmental concerns.

- 1992-COP (CONFERENCE OF PARTIES) came into existence and 1995 it got ratified followed by major first COP (3) in 1997 called Kyoto protocol which was made legally binding for developed nations to pay damages as they have been polluting since the Industrial Revolution[11]
- The next big change was Paris agreement -2015 COP-21 it appealed that all nations come together to keep temp 2deg or min 1.5 degrees lower than pre-industrial phase[11]
- Parallely India and France started ISA (International solar Alliance) to harness solar energy and recently India launched panchamrit COP-26 where it presented the following five nectar elements (Panchamrit) of India's climate action (Nations, 2023) :
    - Reach 500GWNon-fossil capacity by 2030.
    - 50 per cent of its requirements from energy by 2030.
    - Reduction of total projected carbon emissions by one billion tonnes from now to 2030. Reduction of the carbon intensity of the economy by 45 per cent by 2030, over 2005 levels.
    - Achieving the target of net zero emissions by 2070.
- India in accordance with UK, successfully launch OSOWOG -One sun one world one grid (October 2018)
- Post covid India launched PLI (production-linked incentive) to boost different sectors and encourage people to industrialize in India, and reduce our over-dependence on China.
- India has also brought in policies for national green hydrogen missions, and ethanol mixing to reduce oil imports.
- The Govt is supporting EV and aggressively approaching achieving net carbon emission goals until 2070 So EV has players with the support of big industry players like TATA who with open hands invested heavily in building infrastructure.

This will overall help in improving GDP, reducing dependency, attracting global investment, stable economy, better job opportunities and sustainable eco-friendly options

Technical and construction policies related to charging infrastructure, along with government reforms, play a crucial role in raising awareness and enhancing convenience for electric vehicle (EV) adoption. Preferential policies, such as designated parking spaces, free parking, expedited issuance of license plates, and lottery-based or free license plate allocations, also significantly influence consumer behavior. Economic studies highlight the rational decision-making of consumers and how incentives, combined with additional benefits, can increase the intention to adopt new vehicle types. Consequently, factors such as rewards, charging and fuel facilities, and robust infrastructure are key determinants in shaping consumer intentions[12].

It is essential to align policies for the effective adoption of vehicles with both fuel type and customer perception. Acts like the Energy Policy Act play a pivotal role in shaping perceptions and encouraging adoption, particularly when policy incentives and public awareness are emphasized. Providing appropriate financial support, such as reduced registration taxes, exemptions from road tolls, and waivers on value-added or purchase taxes, can significantly boost consumer interest. These measures can lead to higher adoption rates for innovative vehicle types, such as electric or hybrid models[13].

1.3. Highlights of union budget 2023-2024: A supportive government outlook

The "Amrit Kaal" budget – the first budget in the lead-up to India's 100th-year milestone in 2047 – prioritized 'Saptarishi' or seven areas: "**inclusive development, reaching the last mile, infrastructure and**

investment, unleashing the potential green growth, youth and financial sector." The top highlights of the automotive industry are the areas of "**Green Growth**" which include not just green farming and green buildings, but also green fuel, green energy, green equipment, and green mobility[14].

As India sets out to achieve its objective of net zero by 2070, ₹35,000 crores has been allotted to priority capital investments to accelerate low carbon energy transition and improve energy security. Doubling the allocation for FAME-III (Faster Adoption and Manufacturing of Electric Vehicles) scheme with continuing subsidies and incentives for EV manufacturing. Promoting and encouraging domestic lithium-ion battery production to reduce the cost of EV prices, additionally exempting custom duty taxes on the raw materials, capital goods and machinery which is needed for the production of lithium-ion batteries for EVs until March 31, 2024. FAME-III also recognizes the pivotal need for charging Infrastructure and battery technology by involving government initiatives and support from fintech solutions to promote easy **affordability.**

The National Green Hydrogen Mission which was launched recently has received ₹19,700 crores to "facilitate the transition of the economy to low carbon intensity, reduce dependence on fossil fuel imports, and make the country assume technology and market leadership in this sunrise **sector.**

The budget stresses vehicle electrification with progressive action on alternate fuels. With recently launched National Green Hydrogen Mission, along with the target of achieving 5MMT annual production of green hydrogen by 2030, will provide a clear framework for alternative energy adoption. The budget will focus on green growth and sustainable mobility that will help India's Automotive Industry smoothly transition into the more environmentally friendly stage.

An annual plan to increase domestic ethanol production to target the national need for bio-fuels which is laid out in the "Roadmap for ethanol blending 2020-25" will help in cutting down carbon emitted by vehicles and dependency on crude oil imports. The government plans to push its ethanol blending from currently 10% (E10) to 20% (E20) by 2025 production of E20-tuned vehicles will start in April 2025.

With India becoming the 5th largest economy (USD 3.7 Trillion) in 2023 is also the fastest-growing economy in the world which raises the necessary debate of future decisions for growth. We have already seen the past with Gen X who are currently in the age range of 59-44 and Millennials 43-28 are the ones who have come out of a financially and economically struggling nation.

Table 1. Factors affecting the thought process of Gen Z v/s Millenials.

S.No	GEN Z	MILLENNIALS
1.	**Economic Landscape:**	
	Mostly entered jobs after the global financial crisis of 2008, and hence faced economic challenges. It influenced their financial perspectives, creating a preference for economic and flexible options.	Some Millennials might be burdened by student loans, affecting their purchasing power. Affordability and financing options are crucial considerations.
1.	**Environmental Awareness**	
	Millennials tend to have a strong awareness of environmental issues. They are more likely to consider the environmental impact of their choices, including vehicle emissions.	Gen Z is known for its activism, including climate activism. They might place a high value on eco-friendly practices and sustainability. Environmental awareness might be shaped by digital media, making gen Z more inclined towards electric and sustainable vehicle options.

This study aims to understand the decisions made by the current policymakers (Gen Z & Millennials) and also examine the behavior of Gen Z in purchase decision during the transition into sustainable automotive choices. This study will also explore the purchase behavior of Gen Alpha since it will be the future workforce witnessing in the concurrent industry 5.0 moving progressively for the Indian market.

1.4. Technological influence on purchasing decisions of generation Z

Age, gender, expertise, trust, and risk-benefit assessments are crucial in accepting automated vehicles across generations. Driving habits and attitudes toward driving-related technology vary between generations[15]. The intention to buy an advanced vehicle is influenced by various factors such as the buyer's age, safety features, perceived social impact, performance expectations, etc[16].

While technological advancements in the automotive sector influence the purchasing decisions of various generations, government regulations remain a crucial role in the uptake of vehicle technology[17]. The adoption of green innovation may be impeded by a low degree of technical absorption ability[18]. Although Mobility as a Service (MaaS) is projected to considerably alter mobility patterns, it is yet unclear who will adopt this new mobility standard and how it will affect choice of vehicles. Adoption of MaaS may be hampered by two key factors: low technology adoption and high (mobility) ownership needs[19].

The development of sustainable transportation is fueled by technological breakthroughs in areas such as autonomous vehicle capabilities and battery technology[20]. Public transportation, such as buses and trains, is essential for increasing productivity, easing traffic, and lowering pollution[21].

1.5. Generational preferences: Socio-economic and branding impact on consumer behaviour

The purchase of vehicles has been rising quickly and with the changing trend and the pandemic situation, safety has been a major contributing aspect. Economic, socio-demographic, and brand trust aspects are important in influencing customer decisions[22]. Personal values also affect the intention to purchase a car, with different consumer categories showing varying car model preferences. The environmental concern and education positively impact the attitude of generation towards transportation policies for reducing car usage[23].

Families and friends have a great impact on the buying behaviour of rural and urban consumers for automobiles. Rural consumer is more affected by the family choice as compared to the urban counterparts[24]. Due to their plethora of options and more comprehensive worldview than any previous generation, gen alpha has already begun to have a significant influence on purchasing decisions. Alpha children have a say and affect their parents on every purchase, including clothes, cars, dining establishments, etc. Income and habitat (rural or urban) are related when it comes to when to purchase any automobile[25].

Generational preferences in car purchases are greatly influenced by branding and marketing. Purchase decisions and brand preferences are greatly influenced by social reference groups, especially for young executives[26]. The inclinations of members of generations millennial and z towards eco-friendly items are greatly impacted by social media27. Increasingly, before making a purchase, people turn to social media as their primary and first source of information[28]. It has been seen that psychological factors affect the purchasing decisions of automobiles across various generations. Heuristics and biases can have a big impact on customer behavior when it comes to buying auto insurance, with men, younger people, and singles generally being more risk-takers[29].

The analysis on post-purchase behaviors in the automotive industry explains that brand loyalty has been greatly affected by number of dealers visit and consumer research activities' group[30]. In shaping young adults' product preferences and purchase decisions for automobiles, peer influence plays a crucial role. The influence of peer's functions through informational, utilitarian, and value-expressive mechanisms[26].

The study analyzes the purchase trend patterns through the secondary data available from the Ministry of Road Transport and Highways. Vehicles being registered with the RTO throughout the states and union territories of India help in understanding the growth in the automotive market. This data portrays the authenticity of the purchase and can be seen on the timeline of Gen Z. In alignment with the United Nations

Sustainable Development Goals—specifically SDG 12.8 (ensuring awareness for sustainable lifestyles) and SDG 13.2 (integrating climate action into policy)—this study highlights how next-generation preferences, when guided by policy and information, can catalyze sustainable transitions in the global automobile industry

2. Literature review

Brandtner, P., & Freudenthaler-Mayrhofer, D.31 examined changing patterns of customers' needs based on a quantitative survey for Gen Y and Z. This paper emphasized that car manufacturers must adapt existing business models to the customer requirements of Gen Y and Z in terms of better digital interaction, incorporating sustainability, and providing higher individual mobility and ownership solution.

Grzesiuk et al., [32] objective was to identify the relationship between and impact of Generation Z's sustainability behaviors (energy conserving and mobility behaviors) on assessing the importance of the availability of energy-efficient transportation solutions in the city. The study believed that behaviors and attitudes toward sustainability can have a great impact on energy-efficient technological solutions. This study found that mobility-related energy-conserving behaviors, which arise from the choice of modes of transportation for moving around the city, and energy-related sustainable behaviors in the purchase, use, and disposal of electrical appliances, have an impact on the evaluation of the significance of the available energy-efficient mobility solutions.

Pelech & Holendová[33] suggested that different generations of respondents will not have different preferences for using car sharing in different situations. The study involved 741 respondents evenly divided between the three generations analyzed (X, Y, Z). The only scenario in which there were discernible generational disparities was when people would choose to carpool to get to work or school. In other instances, there was no evident generational reliance.

Lin et al., [34] discussed new developments in automotive technology indicate a future where software and sensors will replace humans in the driver's seat. Elmquist & Segrestin[35], explained the adoption of sustainability in the automotive industry is facing the difficulty because of the incompatibility of green technologies with conventional vehicle performance. Genzlinger et al., [36] stated that automotive industry has realized that new mobility patterns, restrictive environment rules, technological advancement have a great impact on their traditional business model. World, (2016) [37] found that industry participants offered electrified and driverless vehicles as a solution to the shifting demands and tastes of consumers and also moving towards mobility applications based on the concept of "as a service. Mola et al., [38] experienced that MaaS indicates a complete change towards the focus on the journey than to focus on the ownership of transportation. Nam et al., [39] suggested that implementation of sustainable transportation alternatives to facilitate public transit access enables the mitigation of traffic congestion and its associated consequences. The options includes Peer-to-peer (P2P) transportation, walking, biking, and ridesharing.

Kaur & Sandhu[40], indicated that Factors like safety, comfort, luxury, reliability, and fuel efficiency too are great influencers for buyers. Oliveira & Dias[41], discovered that Green transportation policies and alternative fuel vehicles (AFVs) are more likely to receive support from higher education levels. There is a positive correlation between customer preferences for AFVs and gender, education level, and size of family. Liu et al., [42] suggested that the major reasons for low adoption towards EV includes battery cost, price of purchase, maintenance cost, payback period, understanding the cost of Lithium batteries , high purchase price makes the vehicle expensive as well.

Anderson et al., [43] discussed that there is a strong correlation between parents' and adult children's automobile brand choices, suggesting intergenerational transmission of brand preferences. Letchumanan &

Sam[44], found that in the automotive sector, consumers' decisions are significantly influenced by brand names, with buyers exhibiting a preference for well-known and branded vehicles. Kiran & Vasantha[45], explained that Economic, functional, and psychological characteristics are among the key issues that influence customer attitudes on car purchases, and social media plays a significant role in this process. Men and women have distinct attitudes on searching for information about cars on social media. Tanaiutchawoot et al., [46] suggested that the purchase of automotive is also affected by the use of nudging strategies like feedback and incentives . Koller et al., [47] recently perceived ecological value from the usage of vehicles has emerged as a crucial factors affecting the loyalty intention of the buyers.

Berfin Ince et al., [48] contributed to understanding the changing mindset and behaviors of Gen Z in attaining the enetertainement within the autonomous vehicle (AVs). The study explored that the meaning of in-car entertainment differs within the minds of Generation Z compared to others. It has revealed eight different mindsets were revealed, which led us to summarize three points that characterize AV's in-car entertainment experience. Most participants imagined themselves engaging with the immersive technology inside the car to entertain themselves. This suggests that designing a digital playground where younger generations can proactively pursue their meaning-making and value actualization within an AV space would be worth considering.

Malhotra Verma [49] revealed that well-being requirements ranking exists among generations X, Y and Z. The study aimed to demonstrate that companies ought to develop tailored retention plans to involve every generation for extended periods and foster a creative atmosphere. The retention tool for the automobile industry was exposed in the form of four dimensions - Extrinsic motivation, intrinsic motivation, Eudemonic needs and Hedonic needs

Atungulu [50] found that participants in Gen Z were statistically significantly influenced by their understanding of environmental sustainability when it came to their preferred delivery vehicle for home delivery. The objective was to understand how access to knowledge about the environment to customers affects their vehicle preferences. Based on this information, retailers can push advertising or design packaging options that inform consumers of the potential impact that the vehicle that is utilized to facilitate their order delivery may have an adverse environmental impact. This finding illustrates that consumers can be influenced not solely by environmental information but by which aspects of environmental sustainability issues are presented to them and how delivery vehicle choice affects that dimension of the environment

Wawer et al. [51] identified the relationship between the evaluation of smart mobility solutions' importance for a smart city, attitudes and behaviors of Generation Z in the context of sustainability, their use of ICT as well as declarations and actual participation in activities in smart cities. The study suggested that there are four main indicators of smart mobility in a smart city, that is, ecological solutions in public transport, amenities for passengers and residents, alternatives to public means of transport and the city's adaptation to their needs, and road traffic. Thus, the study identified the impact of sustainability, information and communication technologies, and participation on indicators of smart mobility.

Bélis-Bergouignan et al., [52]examined the multinational corporation as a learning hierarchy and provided a model that may be used to analyze how these companies are organized spatially. Their approach makes it possible to identify four different types of configuration, archetypes which represent car makers' behavior at various times in their history, either concerning the management of their core competencies or else in terms of the environmental constraints that affected them at the time. The analytical framework made it possible to encompass all of the strategies that companies used when they tried to structure their organization in a way that satisfies spatial considerations.

Salman et al., [53] stated that Mercedes was mostly negatively impacted by various political, economic, social, legal, and environmental factors but technology on the other hand made a major contribution to the success of the brand. It has been established in the paper that the S-class had no violations of the demand laws and the cars were revealed to be price sensitive in the United States. Violations in demand only occurred in 2011-2014 when the quantity demanded increased with the increase in prices. These fluctuations occurred because of constantly changing consumer preferences. On the other hand, supply laws Swere also not violated for the S-class over the decade. Technology and subsidies from the government were the main factors that accelerated Mercedes' production. Various demonstration programs and incentives have been introduced to enhance adoption and mitigate challenges. Nocera & Cavallaro[54], highlighted that financial and preferential policies have a particularly strong influence on the adoption of electric vehicles, especially among the younger generation.

The findings above indicated that while tech-savviness and sustainability have little bearing on Generation Z's decision to purchase electric automobiles, factors like financial benefits, risk, and price have a big influence on the same. Based on these findings, several recommendations emerge for industry stakeholders and policymakers. Firstly, targeting younger demographics through tailored marketing campaigns can capitalize on the strong interest in electric vehicles among Generation Z. Secondly, addressing safety concerns, such as vehicle burn, battery life, and safety features, is crucial to alleviate consumer apprehensions. Thirdly, highlighting the environmental benefits of electric vehicles, such as reducing carbon emissions, can further encourage adoption.

3. Research design

3.1 Objectives of study

1. To study the changing paradigms in Automobile industry with respect to fuel variants.
2. To study the developments in Industry 5.0 and role of government policies in automobile sector in promoting environmentally sustainability.
3. To explore factors affecting consumer preference(across generation z and alpha) and purchase behavior for vehicle variants(socio economic, branding factors)
4. To study government policies, challenges and opportunities for adoption of environmentally sustainable vehicle purchase behavior.

3.2. Type of research - Exploratory and descriptive

3.3. Type of data -Secondary sources

3.4. Purpose and approach of study

With a review of existing literature, a theoretical framework to identify gaps in the current knowledge and to determine studies related to generational preferences, sustainability in the automotive industry, and the influence of government policies on purchasing behavior historical data on vehicle registrations in the analysis is considered as the actual sales of vehicles running on the road. This data is sourced from the Ministry of Road Transport and Highways and helps in understanding the trajectory of sustainable vehicle adoption.

4. Data analysis and findings

Since one of the objective of the study is to identify the factors affecting consumer preference (across generation z and alpha) and purchase behavior for vehicle variants.The following tables and figures demonstrate the usage of vehicle types based on different features and fuel types

Table 2. Diesel vehicle type and adoption.

S No	Vehicle Category	Diesel												
		2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
1	FOUR WHEELER (INVALID CARRIAGE)	63	109	133	89	125	135	209	250	291	113	243	308	361
2	HEAVY GOODS VEHICLE	2,82,965	2,30,050	1,73,981	1,95,967	2,53,031	2,65,977	2,92,563	3,31,439	2,37,745	92,366	1,75,344	2,72,472	2,38,825
3	HEAVY MOTOR VEHICLE	4,853	4,437	4,051	3,533	3,742	4,292	4,000	4,728	5,216	3,812	4,779	5,840	4,718
4	HEAVY PASSENGER VEHICLE	33,588	35,917	31,602	25,601	32,827	39,310	26,690	25,166	32,421	3,964	6,471	11,788	15,974
5	LIGHT GOODS VEHICLE	4,48,060	5,18,711	4,83,622	4,40,409	4,27,474	4,46,068	5,19,130	6,28,131	6,14,821	3,65,283	3,60,268	4,70,097	3,79,451
6	LIGHT MOTOR VEHICLE	14,27,872	16,98,977	16,37,013	16,06,373	14,40,348	14,34,543	15,76,509	15,74,584	14,18,286	11,00,322	12,17,131	14,07,526	12,21,630
7	LIGHT PASSENGER VEHICLE	1,87,894	2,21,609	1,96,171	1,68,068	1,98,562	2,07,174	1,73,381	1,96,638	1,70,152	39,293	51,426	71,355	71,877
8	MEDIUM GOODS VEHICLE	46,611	37,911	27,820	24,038	27,583	31,953	29,564	39,072	37,314	19,738	23,285	29,222	27,960
9	MEDIUM MOTOR VEHICLE	8,088	7,287	5,400	4,503	4,700	6,157	7,943	13,260	14,314	15,109	12,993	11,016	7,887
10	MEDIUM PASSENGER VEHICLE	13,435	15,555	15,414	15,564	17,472	19,350	17,912	19,756	22,758	3,461	4,436	16,428	21,349
11	OTHER THAN MENTIONED ABOVE	42,514	49,819	56,086	50,216	46,882	43,276	43,360	37,996	40,109	42,681	41,673	52,759	58,630
12	THREE WHEELER(NT)	49,898	48,129	35,741	42,680	38,843	34,740	30,275	32,065	36,572	10,690	7,560	15,744	499
13	THREE WHEELER(T)	2,61,644	2,88,456	2,64,668	2,61,689	2,57,928	2,51,403	2,49,740	2,86,820	3,35,823	1,04,572	75,201	84,608	1,08,021
14	TWO WHEELER (INVALID CARRIAGE)	7	7	6	2	9	5	4	2	1	1	1	0	1
15	TWO WHEELER(NT)	3,635	6,849	4,003	3,360	2,611	2,418	1,919	650	338	222	214	106	0
16	TWO WHEELER(T)	2	2	0	2	3	1	3	3	2	1	0	0	0

Source: *vahan.parivahan.gov.in*

Heavy Goods Vehicles and Light passenger vehicles have shown consistent growth from year 2011-12 to 2023-2024 (**Table 1**). An increase of 51.87% can be seen in Heavy goods vehicle and a sharp increase of 316% in light passenger vehicles over this period. Heavy motor vehicles and medium motor vehicles show fluctuations in the data where the purchase was not consistent. Heavy passengers' vehicles experienced a sharp increase from 33,588 in 2011-12 to 1,15,974 in 2023-24. The number of light motor vehicles has also increased to 21,21,630 in 2023-24 from 14,27,872 in 2011-12. Two wheelers (NT), Three wheelers (NT) and two wheelers (T) have relatively low but stable figures during the study period. It can be understood that years from 2011-12 to 2015-16 have shown a steady rise in most of vehicle categories whereas the recent years showed a great increase, especially in light and heavy vehicles. This trend reflects the increasing demand for diesel-powered vehicles in various transportation sectors. The increasing carbon taxes also affect behaviour of consumers and enabling them to shift to diesel from petrol fuel vehicle and also impact price of passenger cars, fuel price, interest rates, income level, population density, inflation, and vehicle stock[55]. When it comes to heavy vehicle in three different categories like Goods, Motor, passenger there has been a mixed sentiment which is on lower side since the difference between the prices of Petrol and Diesel was huge. Thus, it served pockets and enhanced change in adoption. However, considering the environmental hazards and rising threats to environment government kept hiking prices of diesel resulting in low purchase, same was found in all three categories. The trend towards purchase of CNG thus picked understanding economy and less environmental threat[56].

The above table shows the trend in purchase of petrol vehicles four-wheeler, light good, motor and passenger vehicles in last twelve years which is affected by not only increasing population type and size however affected by largely the affect that diesel vehicles brought and curb in its adoption due to rising prices and less motivation keeping environmental aspects in consideration. From 2011 to 2023-24 there has been rise in the purchase of vehicles keeping less negative environmental aspects and better maintenance of vehicles supporting engine type and road or other infrastructural aspects. When it comes to three wheelers vehicles a similar trend has been noticed with purchase and inclination but it gradually reduced in between 2017-21 even if they form a strong base for transportation especially when it comes to local movement and transit but understanding the advent of electric vehicles the purchase was found to be affected. When talked about two wheelers as well a similar uprise has been shown from 2214 units to 1,54,76523 units from 2011-23-24. With rising emission and vast growth of this sector it is also expected that emissions by 20250 will rise thus it becomes important to ensure climate change is not affecting survival hence the transition from diesel to petrol was seen largely[57] **.** This has also given rise to a trend of shifting towards alternate fuel and in coming future efforts towards the progression of these are also expected[58]

Based on the objectives, another purpose was to analyze how the adoption of Petrol and CNG has evolved over time (**Table 3**). Over the past 12 years, there has been a significant increase in the usage and adoption of four-wheelers, with sales rising from 83 to 257 vehicles, indicating rapid growth. Similarly, light goods, motor, and passenger vehicles have also experienced substantial increases, with sales doubling across all three segments. CNG has emerged as a leading fuel due to its low environmental impact, widespread availability, and economical cost. It has been in use for a long time, offering both economic and security benefits[59]. The use of CNG as a transport fuel is not a recent development; there are over 23.5 million natural gas vehicles globally, with Asian countries leading the way with 15.7 million vehicles. This shift has significantly contributed to reducing environmental degradation[60].

The sustained advantages of CNG, including its pivotal role in promoting cleaner energy, provide fleet operators with strong incentives and access to a well-established fueling infrastructure for improved efficiency. In the three-wheeler segment, adoption trends have been mixed. While there was a sharp increase initially, the trend experienced a slight decline due to factors such as the COVID-19 pandemic, lockdowns, and shifts in income patterns.

Table 3. Petrol vehicle type and adoption.

S No	Vehicle Category	Petrol												
		2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
1	FOUR WHEELER (INVALID CARRIAGE)	184	197	216	387	514	726	946	1,007	1,067	1,261	1,732	2,264	2,215
2	HEAVY GOODS VEHICLE	123	108	58	47	46	60	111	36	5	0	1	1	4
3	HEAVY MOTOR VEHICLE	15	20	8	5	3	6	13	46	4	1	0	0	1
4	HEAVY PASSENGER VEHICLE	34	46	26	25	18	31	14	19	3	5	3	4	4
5	LIGHT GOODS VEHICLE	3,187	3,336	3,548	4,241	5,013	4,231	1,968	833	2,479	30,040	46,363	49,347	39,543
6	LIGHT MOTOR VEHICLE	11,06,498	9,31,475	9,52,686	11,16,730	12,78,691	14,51,163	16,60,444	16,79,555	16,52,883	18,23,661	19,60,670	21,74,947	18,27,131
7	LIGHT PASSENGER VEHICLE	11,576	11,373	11,813	12,510	15,683	22,609	24,368	25,315	25,778	17,114	19,560	36,143	59,256
8	MEDIUM GOODS VEHICLE	25	18	10	12	35	18	9	4	2	0	0	0	0
9	MEDIUM MOTOR VEHICLE	32	26	7	8	10	20	14	7	3	4	1	7	4
10	MEDIUM PASSENGER VEHICLE	11	30	7	10	21	22	19	9	6	11	12	0	5
11	OTHER THAN MENTIONED ABOVE	573	381	521	357	301	1,043	1,028	558	1,072	198	125	53	233
12	THREE WHEELER(NT)	2,123	1,123	622	551	597	397	273	177	111	61	42	25	83
13	THREE WHEELER(T)	36,190	26,061	19,529	28,818	23,888	23,544	21,460	23,536	18,898	9,151	8,338	10,811	11,854
14	TWO WHEELER (INVALID CARRIAGE)	936	1,448	2,738	2,852	3,952	3,458	5,425	12,250	11,017	6,680	11,319	16,080	19,116
15	TWO WHEELER(NT)	1,23,87,391	1,30,04,008	1,36,69,880	1,49,44,260	1,55,56,201	1,67,44,434	1,85,42,605	1,94,64,131	1,90,35,524	1,32,37,389	1,32,79,595	1,52,71,825	1,35,08,047
16	TWO WHEELER(T)	2,214	937	1,040	1,051	2,067	3,528	7,327	18,932	16,620	3,203	5,652	16,080	9,027
	Total	13551112	13980587	14662709	16111864	16887040	18255290	20266024	2,12,26,415	2,07,65,472	1,51,28,779	1,53,33,413	1,75,77,587	1,54,76,523

Source: *vahan.parivahan.gov.in*

Table 4. Petrol/CNG vehicle type and adoption.

S No	Vehicle Category	PETROL/CNG												
		2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
1	FOUR WHEELER (INVALID CARRIAGE)	81	79	86	114	136	152	199	192	162	93	148	240	257
2	HEAVY GOODS VEHICLE	5	3	2	7	7	4	3	1	0	0	0	1	0
3	HEAVY MOTOR VEHICLE	0	0	0	0	0	0	0	0	0	0	0	0	0
4	HEAVY PASSENGER VEHICLE	13	7	3	6	5	7	4	0	0	0	0	0	0
5	LIGHT GOODS VEHICLE	2,411	2,110	3,060	4,799	4,068	1,084	987	2,530	4,030	5,534	3,517	2,576	4,522
6	LIGHT MOTOR VEHICLE	1,74,214	1,40,772	1,25,354	1,48,683	1,54,393	1,69,539	1,75,210	1,88,204	1,75,955	1,76,461	2,35,836	3,27,820	3,68,471
7	LIGHT PASSENGER VEHICLE	8,870	7,694	10,234	11,007	23,083	56,552	31,173	48,388	44,294	11,471	20,960	71,602	1,16,486
8	MEDIUM GOODS VEHICLE	5	4	4	1	0	1	0	1	0	0	0	0	0
9	MEDIUM MOTOR VEHICLE	1	0	3	1	0	1	2	0	0	0	0	0	0
10	MEDIUM PASSENGER VEHICLE	10	2	2	6	3	3	0	1	0	0	0	0	0
11	OTHER THAN MENTIONED ABOVE	389	548	196	241	387	268	357	545	563	29	177	59	1
12	THREE WHEELER(NT)	552	309	216	262	3,008	1,079	807	1,476	2,079	198	508	372	11

S No	Vehicle Category	PETROL/CNG												
13	THREE WHEELER(T)	49,227	71,050	59,229	90,439	90,834	1,01,367	1,70,932	1,95,136	1,78,562	14,247	16,151	18,599	2,298
14	TWO WHEELER (INVALID CARRIAGE)	2	0	1	0	0	1	1	0	0	0	1	0	0
15	TWO WHEELER(NT)	1,124	671	768	1,011	678	1,041	441	214	103	38	39	15	0
16	TWO WHEELER(T)	0	0	0	1	0	1	1	0	0	0	0	0	0
	Total	236904	223249	199158	256578	276602	331100	380117	436688	405748	208071	277337	421284	492046

Table 4. (*Continued*)

Source: *vahan.parivahan.gov.in*

Table 5. CNG vehicle type and adoption.

S No	Vehicle Category	CNG ONLY												
		2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
1	FOUR WHEELER (INVALID CARRIAGE)	0	1	0	2	0	0	0	0	0	0	1	0	0
2	HEAVY GOODS VEHICLE	1,706	1,704	1,577	1,031	1,134	901	683	441	929	1,680	10,998	8,240	4,292
3	HEAVY MOTOR VEHICLE	1	1	0	0	0	1	3	0	2	0	1	2	1
4	HEAVY PASSENGER VEHICLE	2,004	1,633	2,221	1,351	1,190	1,943	1,412	1,511	3,646	545	897	1,898	1,038
5	LIGHT GOODS VEHICLE	7,541	6,480	5,591	5,626	6,258	10,433	15,083	21,493	21,023	17,015	70,309	75,766	57,522
6	LIGHT MOTOR VEHICLE	1,925	1,671	1,532	2,225	2,064	1,386	411	266	184	37	67	98	54
7	LIGHT PASSENGER VEHICLE	4,230	2,460	720	600	1,550	1,243	1,730	1,955	1,549	132	105	1,464	1,642
8	MEDIUM GOODS VEHICLE	426	256	275	158	149	882	2,244	4,129	4,504	4,740	13,948	7,578	3,315
9	MEDIUM MOTOR VEHICLE	1	0	0	0	0	0	2	1	2	6	6	4	3
10	MEDIUM PASSENGER VEHICLE	353	371	434	327	392	516	779	516	1,073	238	781	2,889	2,215

S No	Vehicle Category	CNG ONLY												
11	OTHER THAN MENTIONED ABOVE	13	6	16	12	18	12	12	21	17	23	9	6	11
12	THREE WHEELER(NT)	2	2	1	3	71	14	13	2	23	457	1,413	5,854	584
13	THREE WHEELER(T)	11,288	10,551	9,745	13,118	14,155	10,983	5,022	2,005	5,193	35,388	1,07,143	2,20,874	2,95,673
14	TWO WHEELER (INVALID CARRIAGE)	0	0	0	0	0	0	0	0	0	0	0	0	0
15	TWO WHEELER(NT)	4	12	9	18	44	40	39	9	4	2	0	0	0
16	TWO WHEELER(T)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	29494	25148	22121	24471	27025	28354	27433	32349	38149	60263	205678	324673	366350

Table 5. (*Continued*)

Source: *vahan.parivahan.gov.in*

Table 4 provides insights into the adoption trends of heavy goods and heavy passenger vehicles between 2011 and 2023-24. The data reveals a mixed adoption pattern, with periods of slower growth during this time. This slowdown can be attributed to consumer hesitation regarding the use of CNG vehicles, as well as concerns about design limitations potentially affecting vehicle speed, which may vary based on the customers' location and preferences. Light goods vehicles experienced a significant increase in adoption, while light passenger vehicles showed a more mixed trend for similar reasons. Medium goods vehicles demonstrated remarkable growth, followed by a notable rise in the adoption of three-wheelers, which is particularly commendable. Overall, it is evident that the adoption of CNG vehicles has undergone a transformative shift, paving the way for a safer, more sustainable, and environmentally friendly future in transportation.

In **Table 5**, Light Goods Vehicles, Light Motor vehicles, Three Wheelers (T) and Light passenger vehicles have seen a continuous increase in the demand of the electric vehicles. The demand for these vehicles have increased in last 3 years i.e. from year 2021-22 to 2023-24. Potential customers place a high value on a vehicle's performance, particularly its driving range and safety and the concern for the environment is highly responsible for the increase in the adoption of electric vehicles[61]. For all other categories there was no such demand in Electric vehicle category but in last 2 years the demand for Heavy passenger vehicles in EV category can be seen. The EV vehicles for Two Wheelers (NT and T) have a fluctuating trend till 2017 but after 2017 they have seen and upward trend except for year 2020-21. The financial crisis and the stock market's collapse, particularly during COVID 19, also encouraged many to choose electric automobiles. The consumers can afford EVs because of the aid provided by government subsidies and incentives[62]

Table 6 reflects the purchasing preference of Generation Z towards the Four-Wheeler (Invalid Carriage), Light Motor Vehicles and light passenger vehicles. Initially from year 2011 to 2015, there was no such demand for such cars. The increase in buying of such vehicles has been increasing from 2015 onward. Maximum consumption of such automobiles can be seen in post covid period. There is a growing interest in green vehicles due to environmental concern where the perception and awareness of consumers play a crucial role[63]. Since petrol and diesel consumption leads to air pollution and climate change and impacts the environment and public health, there is a shift towards alternative fuel including hybrid/electric vehicles[64].

The above table (**Table 7**) indicates the purchase of automobiles only in the year 2023 and it has rapidly increased in the year 2024 by huge numbers. The purchase is only for the two-wheeler category. One major reason for such an increase could be the government policy initiatives for blending ethanol with petrol with the aim of 20% by 2025. This has driven the increase in production and sales of petrol/ethanol vehicles though only in the two-wheeler category as per this data. It's anticipated that the ethanol blending scheme will improve energy security, help regional farmers and businesses, and lower vehicle emissions[65]

Table 6. Electric vehicle type and adoption.

S No	Vehicle Category	ELECTRIC(BOV)												
		2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
1	FOUR WHEELER (INVALID CARRIAGE)	0	0	0	0	3	2	0	0	0	0	5	15	42
2	HEAVY GOODS VEHICLE	23	12	17	6	4	7	0	0	0	0	0	206	157
3	HEAVY MOTOR VEHICLE	9	8	1	1	1	8	1	0	0	0	0	1	2
4	HEAVY PASSENGER VEHICLE	1	0	1	0	2	0	26	53	363	217	1,067	1,937	2,621
5	LIGHT GOODS VEHICLE	80	111	105	59	52	326	920	512	55	47	1,163	922	2,611
6	LIGHT MOTOR VEHICLE	830	374	546	672	750	734	1,003	1,228	1,041	4,801	17,676	40,431	65,849
7	LIGHT PASSENGER VEHICLE	22	19	30	10	119	145	317	662	1,340	360	961	7,121	8,197
8	MEDIUM GOODS VEHICLE	1	5	1	1	3	3	1	3	0	0	0	0	0
9	MEDIUM MOTOR	0	2	2	0	2	0	0	2	0	0	0	1	5

S No	Vehicle Category	ELECTRIC(BOV)												
	VEHICLE													
10	MEDIUM PASSENGER VEHICLE	0	0	0	0	2	0	9	22	120	156	127	47	270
11	OTHER THAN MENTIONED ABOVE	9	8	8	11	90	558	436	424	778	1,050	1,792	2,350	18
12	THREE WHEELER (NT)	4	0	1	2	1	13	47	95	173	144	346	525	161
13	THREE WHEELER (T)	30	28	28	12	13,683	52,678	91,741	1,15,926	1,42,887	90,789	1,83,194	4,01,592	5,25,985
14	TWO WHEELER (INVALID CARRIAGE)	0	1	0	0	1	0	1	34	3	3	4	27	42
15	TWO WHEELER (NT)	6,645	3,465	1,882	1,569	1,469	1,393	2,002	26,928	25,260	43,159	2,50,199	7,25,304	7,29,983
16	TWO WHEELER (T)	0	1	0	0	0	0	3	1,077	1,582	1,675	2,723	2,938	1,806
	Total	7654	4034	2622	2343	16182	55867	96507	146966	173602	142401	459257	1183417	1337749

Table 6. (*Continued*)

Source: vahan.parivahan.gov.in

Table 7. Petrol/Hybrid vehicle type and adoption

No	Vehicle Category	PETROL/HYBRID												
		2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
1	FOUR WHEELER (INVALID CARRIAGE)	0	0	0	0	0	0	0	9	33	49	68	96	140
2	LIGHT MOTOR VEHICLE	1	3	3	4	166	628	609	29,107	74,388	99,674	1,13,578	2,58,597	2,57,758
3	LIGHT PASSENGER VEHICLE	1	3	0	2	1	23	28	204	816	547	1,131	3,961	7,208
	Total	2	6	3	6	167	651	637	29320	75237	100270	114777	262654	265106

Source: *vahan.parivahan.gov.in*

Table 8. Petrol/Ethanol vehicle type and adoption.

S No	Vehicle Category	PETROL/ETHANOL												
		2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
1	TWO WHEELER(NT)	1	2	1	4	0	2	1	1	4	1	0	13,378	4,26,216
2	TWO WHEELER(T)	0	0	0	0	0	0	0	0	0	0	0	131	3,083
	Total	1	2	1	4	0	2	1	1	4	1	0	13509	429299

Source: vahan.parivahan.gov.in

Understanding the rising trend in vehicle ownership and consumption patterns, along with the alarming increase in oil consumption—projected to reach 17%—highlights the critical need for the adoption of electric vehicles (EVs). According to the International Energy Agency, if current trends persist, oil consumption could surge to 808 million tons, leading to a significant increase in CO2 emissions and environmental degradation[13]. Following the Paris Agreement, countries like China have demonstrated leadership by committing to reduce emissions by 60–65% by 2030, contributing significantly to controlling environmental pollution[66].

Another objective of the study was to study the government policy, challenges and opportunities along with future of automobile industry, the succeeding paragraph highlights the attainment of objective.

Policies promoting vehicle adoption significantly influence consumer behavior, shaped by factors such as energy consumption, environmental emissions, and social, cultural, economic, and financial considerations. Theories like the Theory of Planned Behavior play a critical role in understanding customer decisions, as they analyze attitudes, subjective norms, and perceived behavioral control, which collectively drive intentions and resulting behaviors[67]

Research has shown that preferential and financial policies significantly influence adoption behavior and the effectiveness of policy implementation. The government plays a crucial role in providing appropriate financial and preferential support to encourage behavioral shifts toward sustainable purchasing decisions[68].

Cross-country comparisons reveal that Norway has significantly promoted electric vehicles (EVs), achieving a market share of 79.3%. This success is attributed to substantial support measures, including subsidies, tax rebates, exemptions from congestion fees, and road toll waivers, all aimed at enhancing EV adoption behavior. In the United States, while efforts to address the greenhouse effect and reduce carbon emissions are underway, the pace of EV adoption remains moderate. By 2030, the government aims for over 50% of car sales to consist of zero-emission vehicles. To encourage adoption, incentives such as sales tax exemptions, reduced licensing taxes, and access to carpool lanes are being actively promoted[69]

In the UK, the automobile industry accounts for over 34% of carbon emissions. With new policies in place, the goal is to institutionalize zero-emission vehicles (ZEVs) by 2035, while also reducing the costs associated with driving and maintaining ZEVs. Europe has paved a motivated path toward becoming a climate-neutral continent. Following the 2015 Paris Agreement, the adoption of electric vehicles (EVs) became a top priority, with attractive subsidies offered to encourage uptake. In the United States, the focus is on federal tax incentives, while the UK emphasizes reducing new fossil fuel car sales and offering grants for EV purchases[70]

Thus when it comes to purchasing decisions and awareness, the role of policies and their implications on customers is crucial, particularly in areas such as customer perceptions—whether economic, infrastructure-related, environmental safety, vehicle performance and design, or socio-demographic factors[71]. In India, various measures and strategies have been implemented to encourage the selection of environmentally safe and secure fuel-based vehicles. These include the rapid adoption and manufacturing of hybrid and electric vehicles, along with several incentives to support this shift. Tax incentives, such as reduced GST on hybrid vehicles and performance-linked incentives with direct tax benefits, are also in place. Additionally, a zero-emission trucking policy provides direct tax benefits to

consumers purchasing hybrid or EV vehicles, promoting cleaner, more sustainable transportation and contributing to a revolution in the sector.

5. Findings and discussion

- It can be observed the decline in the purchase of diesel after a plea made by the Ministry of Petroleum and Natural Gas. The plea submitted forced the idea of banning diesel passenger vehicles by 2027 in Indian cities.
- The policy to discontinue of private passenger vehicles after 10 years in metropolitan areas has affected the diesel vehicle sales drastically. This change can be witnessed in **Table 1** as we see the trend falling after stronger policies are being implemented against the favor of diesel vehicles.
- The reason for big sales of diesel cars earlier was the lower price of diesel than petrol by around INR 20-25. Now the difference is barely INR 5-7, the share for diesel is two-fifths. Among the whole refined fuel industry. 80% of that share is used in the transportation sector. In the FY13 the share was 58% as per Society of Indian Automobile Manufacturer (SIAM) PV reports for diesel cars. The diesel car share in FY17 was 40% among the whole passenger vehicle (PV) sales, while it declined to less than 17% in FY21. It is now lower than 19% in the FY23.
- A drop in the sales of petrol vehicles (**Table 2**) can be witnessed due to rise in prices of petrol in recent years. Buyers prefer to buy more economical options like Petrol/CNG (**Table 3**), Petrol/Ethanol (**Table 7**), Electric vehicles (**Table 5**) or Hybrid vehicles (Table 6). They not only are economical for the buyer but these vehicles also help in developing better ecological surroundings.
- The data shows the interest of buyer growth in the petrol/ethanol segment (**Table 7**) after the government promotes sustainability mobility in the "roadmap for ethanol blending".
- With the introduction of electric and hybrid vehicles policies in 2015 a linear growth from 2015-2024 was seen, even though the price of hybrid vehicles is higher than the petrol/diesel vehicles.
- The biggest trend in the current year is the sales of EV vehicles. Even though the sales were very slow from 2015-2021 but recent infrastructure developments in EVSE (Electric Vehicles Supply Equipment) have changed the buyer perspective on the Electric vehicles and a huge jump in sales can be observed.
- Scrapping of vehicles older than 20 years is being supported by the government in way of giving consumers the scrap value of 4-6% of the vehicle's ex-showroom price, state nay also rebate on road tax up to 22% for personal vehicles and up to 15% on commercial vehicles.
- Registration fee may also be waived for new purchase of vehicle against the scrapping certificate. Such government incentives have enabled and encouraged new buy to discontinue the use of high carbon emitting vehicle and switch towards more eco- friendly vehicles.
- Other factors influencing customer perceptions toward the adoption of EVs and other vehicles in this generation include battery range, the reliability of charging stations, and charging time.

Financial, technical, and infrastructural attributes are key factors that significantly impact vehicle adoption[5].

- Studies have identified additional factors influencing vehicle adoption behavior, including power generation, usage restrictions, marketing strategies, customer awareness, consumer knowledge, availability of infrastructural support, capital investment in infrastructure development, misconceptions about vehicle and fuel types, and consumer experience[45]
- It has been found that customer motivation to adopt vehicles can be either intrinsic or extrinsic. Intrinsically motivated customers are driven by personal values, while extrinsically motivated customers are influenced by incentives, such as financial plans or energy-efficient vehicle labels. Government incentives have proven effective in many countries. A survey of 14 countries revealed that tax subsidies and incentives significantly influence adoption behavior, especially among newer generations[72]

6. Future implications

The study extensively explores the generational dynamics within the Indian automotive sector, focusing on Millennials, Generation Z, and offering insights into potential implications for Generation Alpha.. It examines the Union Budget's allocation of funds, incentives for electric vehicles (EVs), and initiatives like the National Green Hydrogen Mission, offering a comprehensive understanding of the policy landscape.

The automotive industry is transforming significantly, driven by rapid changes and innovations. Key advancements include autonomous driving, which promises a unique and independent driving experience, shared mobility options that make transportation more affordable, enhanced connectivity for efficient traffic management, and improved infrastructure to support these developments.

Other anticipated changes include the emergence of a hyperconnected society, where real-time connectivity is enabled by IoT, and the impact of a hyper-aging population, with greater focus on older customers, such as those over 65 and the baby boomer generation, becoming crucial for car manufacturers. Additionally, new mobility options, including wearable robots and advanced in-car services, are set to revolutionize the automotive industry

The role of manufacturers and policymakers in ensuring the growth and sustainability of the automobile industry is pivotal. This includes establishing regulations that address vehicle design, equipment standards, safety, and performance. Offering incentives and promoting sustainable development are also essential to encourage customers to adopt environmentally friendly practices.It is crucial for policymakers to implement measures that encourage manufacturers to prioritize average fuel efficiency, advanced driving and control systems, and adherence to regulatory standards for cleaner fuels and catalytic converters. Embracing digital transformation and AI-driven platforms is equally important, as customized algorithms can facilitate the integration of blockchain technology, enhancing efficiency and transparency across the industry.

Scrutinizing market dynamics, the research illuminates trends in vehicle sales through the data of vehicle registrations. It provides valuable insights into how the decisions made by current policymakers

and consumers may shape the preferences and choices of the upcoming generation. Sustainability across the automotive value chain is a key aspect explored, encompassing eco-friendly operations, processes, products, and services.

7. Limitations

The study heavily relies on secondary data, primarily sourced from governmental reports, academic research, and industry publications. The availability and reliability of data are contingent on the transparency and comprehensiveness of these sources..

Individual variations in socio-economic status, geographic location, and personal values may not be fully captured by the broad generational categorizations. Technological influences on consumer choices are recognized but not exhaustively explored.

Barriers to adoption, regulatory hurdles, and industry responses to policy changes are complex and multifaceted. Detailed assessment of the specific environmental impacts of different vehicular choices or manufacturing processes is not conducted in the study.

8. Conclusion

The automotive landscape in India is at a historic crossroads, where generational shifts, governmental policies, financial considerations, and market dynamics intersect to pave the way for a transformative journey towards sustainable mobility.

The substantial allocation of funds to expedite the low-carbon energy transition and the augmented resources for the Faster Adoption and Manufacturing of Electric Vehicles (FAME-III) scheme underscore a proactive approach to fostering green mobility. The National Green Hydrogen Mission, buoyed by significant financial backing, stands as a beacon of India's commitment to reducing dependence on fossil fuel imports.

Due to factors like sky-high fuel prices and an increase in up-front cost of vehicles, buyers are seeking relief with purchasing CNG vehicles. Approach towards leasing, carpooling and easier loan processing and other ownership models have also impacted the mindset of Gen Z towards financially supporting the eco-friendly vehicles.

The government of India launched the National Electric Mobility Mission Plan (NEMMP) 2020 in 2013. It aims to achieve national fuel security by promoting hybrid and electric vehicles in the country. There is an ambitious target to achieve 6-7 million sales of hybrid and electric vehicles year on year from 2020 onwards.

The surge in sales of Petrol/Ethanol vehicles post the introduction of the 'roadmap for ethanol blending' points to a growing interest in sustainable mobility options. However, the most transformative trend lies in the accelerated adoption of Electric Vehicles. The slow growth witnessed from 2015 to 2021 undergoes a seismic shift, with recent infrastructure developments in Electric Vehicle Supply Equipment (EVSE) transforming buyer perspectives.

The Electric Vehicle (EV) revolution, once on the fringes, has now assumed center stage in the Indian automotive narrative. The data (**Table 5**) paints a compelling picture of a rapidly growing market,

spurred by government incentives, infrastructure development, and a shifting consumer mindset. EVs, once considered a niche choice, have now become a viable and attractive option for a growing segment of consumers.

The government's emphasis on the National Green Hydrogen Mission, along with ambitious targets for green hydrogen production, positions India on the cusp of a green energy revolution. The introduction of EV and hybrid vehicle policies, coupled with the commitment to increasing domestic lithium-ion battery production, provides a clear roadmap for a sustainable and eco-friendly automotive future.

As the wheels of change turn, India's automotive sector finds itself steering towards a future where innovation, policy foresight, and generational values converge to shape a new era of sustainable and responsible mobility. The road ahead is not just a passage; it is a transformative journey towards a greener, cleaner, and more sustainable tomorrow.

Future scope of study

The current study analyzes the perspective of Generation Z for automotive preferences with a focus on environmental sustainability. However, the future study can be based on primary data by conducting a survey or interviews with Gen Z and Gen Alpha consumers. Perspective of industry stakeholders like automobile manufacturers, dealers and policy experts can be captured to get the practical insight for promoting sustainable mobility. Rigorous analysis of the policy outcomes, discussing successes and failures of various government initiatives, can also be done in this perspective. Also state state-level policies and various regional government initiatives can be discussed in detail to see the impacts on the automotive preferences.

Declaration of conflicting interests

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References

1. Geels FW. A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. Journal of Transport Geography. 2012;24:471-482. doi:10.1016/j.jtrangeo.2012.01.021
2. Kapferer JN, Michaut-Denizeau A. Are millennials really more sensitive to sustainable luxury? A cross-generational international comparison of sustainability consciousness when buying luxury. Journal of Brand Management. 2019;27(1):35-47. doi:10.1057/s41262-019-00165-7
3. Miglani S. The growth of the Indian automobile industry: Analysis of the roles of government policy and other enabling factors. In: ARCIALA Series on Intellectual Assets and Law in Asia. ; 2019:439-463. doi:10.1007/978-981-13-8102-7_19
4. Nagy J, Jámbor Z. Competitiveness in global trade: The case of the automobile industry. Economic Annals. 2018;63(218):61-84. doi:10.2298/eka1818061n
5. Wang L, Zhang Q, Wong PPW. Purchase intention for green cars among Chinese millennials: Merging the Value–Attitude–Behavior Theory and Theory of Planned Behavior. Frontiers in Psychology. 2022;13. doi:10.3389/fpsyg.2022.786292.
6. Szász L, Csíki O, Rácz BG. Sustainability management in the global automotive industry: A theoretical model and survey study. International Journal of Production Economics. 2021;235:108085. doi:10.1016/j.ijpe.2021.108085.
7. Shidore S, Busby JW. One more try: The International Solar Alliance and India's search for geopolitical influence. Energy Strategy Reviews. 2019;26:100385. doi:10.1016/j.esr.2019.100385

8. D'Costa AP. Globalisation, crisis and industrial relations in the Indian auto industry. International Journal of Automotive Technology and Management. 2011;11(2):114. doi:10.1504/ijatm.2011.039540
9. Eckart, J., & Muehlon, F. Here's how electric vehicles can keep us on the road to Paris. In World Economic Forum. Retrieved from https://www. weforum. org/agenda/2020/09/heres-how-electric-vehicles-can-keepus-on-the-road-to-paris.
10. Azevedo S, Barros M. The application of the triple bottom line approach to sustainability assessment: The case study of the UK automotive supply chain. Journal of Industrial Engineering and Management. 2017;10(2):286. doi:10.3926/jiem.1996
11. ICWA. (2016). Outcome and Indian stance in COPs 1 - 21. Indian Council of World Affairs (Government of India). https://www.icwa.in/show_content.php?lang=1&level=3&ls_id=607&lid=551
12. Franke T, Krems JF. What drives range preferences in electric vehicle users? Transport Policy. 2013;30:56-62. doi:10.1016/j.tranpol.2013.07.005
13. He X, Zhan W, Hu Y. Consumer purchase intention of electric vehicles in China: The roles of perception and personality. Journal of Cleaner Production. 2018;204:1060-1069. doi:10.1016/j.jclepro.2018.08.260.
14. Nations, U. (2023). COP26: Together for our planet. United Nations. https://www.un.org/en/climatechange/cop26 .
15. Ward C, Raue M, Lee C, D'Ambrosio L, Coughlin JF. Acceptance of automated driving across generations: the role of risk and benefit perception, knowledge, and trust. In: Lecture Notes in Computer Science. ; 2017:254-266. doi:10.1007/978-3-319-58071-5_20.
16. Topolšek D, Babić D, Babić D, Ojsteršek TC. Factors influencing the purchase intention of autonomous cars. Sustainability. 2020;12(24):10303. doi:10.3390/su122410303.
17. Rubenstein AH, Ettlie JE. Innovation among suppliers to automobile manufacturers: an exploratory study of barriers and facilitators1. R and D Management. 1979;9(2):65-76. doi:10.1111/j.1467-9310.1979.tb00137.x.
18. Williander M. Fading eco-benign networks. European Journal of Innovation Management. 2006;9(1):92-107. doi:10.1108/14601060610640041.
19. Alonso-González MJ, Hoogendoorn-Lanser S, Van Oort N, Cats O, Hoogendoorn S. Drivers and barriers in adopting Mobility as a Service (MaaS) – A latent class cluster analysis of attitudes. Transportation Research Part a Policy and Practice. 2019;132:378-401. doi:10.1016/j.tra.2019.11.022.
20. Etukudoh NEA, Adefemi NA, Ilojianya NVI, Umoh NAA, Ibekwe NKI, Nwokediegwu NZQS. A Review of sustainable transportation solutions: Innovations, challenges, and future directions. World Journal of Advanced Research and Reviews. 2024;21(1):1440-1452. doi:10.30574/wjarr.2024.21.1.0173.
21. Yannis G, Chaziris A. Transport system and infrastructure. Transportation Research Procedia. 2022;60:6-11. doi:10.1016/j.trpro.2021.12.002.
22. Shetty S. Factors impacting Purchase Behaviour of Automobiles Post Covid-19. Psychology and Education Journal. 2021;57(9):6154-6161. doi:10.17762/pae.v57i9.2690.
23. Kim J, Schmöcker JD, Fujii S. Exploring the relationship between undergraduate education and sustainable transport attitudes. International Journal of Sustainable Transportation. 2014;10(4):385-392. doi:10.1080/15568318.2014.961108.
24. Singh J. Influences on Rural and Urban Consumer Buying. Global Journal of Management and Business Research. 2012;12(7):35-42.
25. Thomas MR, George G. Segmenting, targeting, and positioning (stp) ofgenerational cohorts Y, Z and Alpha. IIMS J Manag Sci. 2021;12(2):115-129. doi:10.5958/0976-173x.2021.00008.7.
26. Reza SA, Valeecha S. Influence of social reference groups on automobile buying decision-research on young executives. World review of business research. 2013;3(4):197-210.
27. Hasdiansa IW, Hasbiah S, Aswar NF. PENGARUH MEDIA SOSIAL TERHADAP PERILAKU PEMBELIAN RAMAH LINGKUNGAN GENERASI MILENIAL DAN GENERASI Z. jbk.
28. Mahrous AA. Implications of the use of social media for pre-purchase information searches for automobiles. International Journal of Technology Marketing. 2016;11(3):254. doi:10.1504/ijtmkt.2016.077361.
29. Graminha PB, Afonso LE. Behavioral Economics and Auto Insurance: The role of Biases and Heuristics. Revista De Administração Contemporânea. 2022;26(5). doi:10.1590/1982-7849rac2022200421.en.
30. Chandrasekharan R, McCarthy PS, Wright GP. Structural models of brand loyalty with an application to the automobile market. Transportation Research Part B Methodological. 1994;28(6):445-462. doi:10.1016/0191-2615(94)90014-0.

31. Brandtner, P., & Freudenthaler-Mayrhofer, D. Business model innovation in the automotive industry-socio-cultural trends in generation Y & Z. In ISPIM Conference Proceedings (pp. 1-17). The International Society for Professional Innovation Management (ISPIM).
32. Grzesiuk K, Jegorow D, Wawer M, Głowacz A. Energy-Efficient City Transportation Solutions in the context of Energy-Conserving and Mobility Behaviours of Generation Z. Energies. 2023;16(15):5846. doi:10.3390/en16155846.
33. Pelech P, Holendová J. Generation X, Y, and Z preferences for Car-Sharing in different situations. ACC Journal. 2022;28(2):86-95. doi:10.15240/tul/004/2022-2-007.
34. Lin, P.-S., Wang, Z., & Guo, R. Impact of connected vehicles and autonomous vehicles on future transportation. Bridging the East and West. 2016 :46-53. https://doi.org/10.1061/9780784479810.006
35. Elmquist M, Segrestin B. Sustainable development through innovative design: lessons from the KCP method experimented with an automotive firm. International Journal of Automotive Technology and Management. 2009;9(2):229. doi:10.1504/ijatm.2009.026399.
36. Genzlinger F, Zejnilovic L, Bustinza OF. Servitization in the automotive industry: How car manufacturers become mobility service providers. Strategic Change. 2020;29(2):215-226. doi:10.1002/jsc.2322.
37. World, A. (2016, March 18). Eight disruptive trends shaping the auto industry of 2030. Automotive World. https://www.automotiveworld.com/articles/eight-disruptive-trends-shaping-auto-industry-2030/.
38. 38 Mola L, Berger Q, Haavisto K, Soscia I. Mobility as a service: An Exploratory study of consumer mobility behaviour. Sustainability. 2020;12(19):8210. doi:10.3390/su12198210 .
39. Nam D, Yang D, An S, Yu JG, Jayakrishnan R, Masoud N. Designing a Transit-Feeder System using Multiple Sustainable Modes: Peer-to-Peer (P2P) Ridesharing, Bike Sharing, and Walking. Transportation Research Record Journal of the Transportation Research Board. 2018;2672(8):754-763. doi:10.1177/0361198118799031
40. Kaur M, Sandhu HS. Factors Influencing Buying Behaviour-A Study of Passenger Car Market. Paradigm a Management Research Journal. 2004;8(2):26-30. doi:10.1177/0971890720040205.
41. Oliver HH, Gallagher KS, Tian D, Zhang J. China's fuel economy standards for passenger vehicles: Rationale, policy process, and impacts. Energy Policy. 2009;37(11):4720-4729. doi:10.1016/j.enpol.2009.06.026.
42. Liu X, Sun X, Zheng H, Huang D. Do policy incentives drive electric vehicle adoption? Evidence from China. Transportation Research Part a Policy and Practice. 2021;150:49-62. doi:10.1016/j.tra.2021.05.013.
43. Anderson S, Kellogg R, Langer A, Sallee J. The Intergenerational Transmission of Automobile Brand Preferences: Empirical Evidence and Implications for Firm Strategy.; 2013. doi:10.3386/w19535.
44. Letchumanan, Gomathi. A Study on the Influence of Brand Name on Purchase of Automobile in Malaysia. Global Business & Management Research. 2016; 8 (3).
45. Kiran P, Vasantha S. Transformation of Consumer Attitude through Social Media towards Purchase Intention of Cars. Indian Journal of Science and Technology. 2016;9(21). doi:10.17485/ijst/2016/v9i21/92608
46. Tanaiutchawoot N, Bursac N, Rapp S, Albers A, Heimicke J. NUDGES: an assisted strategy for improving heuristic decision in PGE-Product Generation Engineering. Procedia CIRP. 2019;84:820-825. doi:10.1016/j.procir.2019.04.294.
47. Koller M, Floh A, Zauner A. Further insights into perceived value and consumer loyalty: A "Green" perspective. Psychology and Marketing. 2011;28(12):1154-1176. doi:10.1002/mar.20432.
48. Ince EB, Cha K, Cho J. An investigation into generation Z's mindsets of entertainment in an autonomous vehicle. Entertainment Computing. 2023;46:100550. doi:10.1016/j.entcom.2023.100550.
49. Verma, P. M. Generational differences in retention strategies: A study in the automobile industry. Journal of Multidimensional Research & Review. 2020; 1(2): 27-42 . http://www.jmrr.org
50. Atungulu, M. Investigating the Effect of Knowledge of Environmental Implications on Generation Z Vehicle Choice in Last Mile Delivery Service. Supply Chain Management Undergraduate Honors Theses. 2023. https://scholarworks.uark.edu/scmtuht.
51. Wawer M, Grzesiuk K, Jegorow D. Smart mobility in a smart city in the context of Generation Z sustainability, use of ICT, and participation. Energies. 2022;15(13):4651. doi:10.3390/en15134651.
52. Belis-Bergouignan MC, Bordenave G, Lung Y. Global strategies in the automobile industry. Regional Studies. 2000;34(1):41-53. doi:10.1080/00343400050005871
53. Salman D, Yasser N, Raafat A. INSIGHTS FROM THE AUTOMOTIVE INDUSTRY – THE CASE OF THE MERCEDES S-CLASS IN THE UNITED STATES. Economics & Law. 2022;4(1):15-27. doi:10.37708/el.swu.v4i1.2.
54. Nocera S, Cavallaro F. The competitiveness of alternative transport fuels for CO2 emissions. Transport Policy. 2016;50:1-14. doi:10.1016/j.tranpol.2016.05.013.

55. Nadirov O, Vychytilová J, Dehning B. Carbon taxes and the composition of new passenger car sales in Europe. Energies. 2020;13(18):4631. doi:10.3390/en13184631.
56. Mishal A, Dubey R, Gupta OK, Luo Z. Dynamics of environmental consciousness and green purchase behaviour: an empirical study. International Journal of Climate Change Strategies and Management. 2017;9(5):682-706. doi:10.1108/ijccsm-11-2016-0168
57. Creutzig F, Jochem P, Edelenbosch OY, et al. Transport: A roadblock to climate change mitigation? Science. 2015;350(6263):911-912. doi:10.1126/science.aac8033
58. Rezvani Z, Jansson J, Bodin J. Advances in consumer electric vehicle adoption research: A review and research agenda. Transportation Research Part D Transport and Environment. 2014;34:122-136. doi:10.1016/j.trd.2014.10.010
59. Askin AC, Barter GE, West TH, Manley DK. The heavy-duty vehicle future in the United States: A parametric analysis of technology and policy tradeoffs. Energy Policy. 2015;81:1-13. doi:10.1016/j.enpol.2015.02.005.
60. Khan MI, Yasmeen T, Khan MI, Farooq M, Wakeel M. Research progress in the development of natural gas as fuel for road vehicles: A bibliographic review (1991–2016). Renewable and Sustainable Energy Reviews. 2016;66:702-741. doi:10.1016/j.rser.2016.08.041.
61. Thananusak T, Rakthin S, Punnakitikashem P, Tavewatanaphan T. Factors affecting the intention to buy electric vehicles: empirical evidence from Thailand. International Journal of Electric and Hybrid Vehicles. 2017;9(4):361. doi:10.1504/ijehv.2017.10011120.
62. Wang Z. The Growing Preference for Electric Vehicles from a Political and Economic Point of View. Journal of Education Humanities and Social Sciences. 2023;22:620-624. doi:10.54097/ehss.v22i.13241.
63. Upadhyaya A, Dua S. Consumer awareness and perception towards hybrid cars. JIMS8M the Journal of Indian Management & Strategy. 2019;24(3):46. doi:10.5958/0973-9343.2019.00024.3.
64. Rizwan M, Karthikeyan K. Analyzing the Environmental and Public Health Impacts of Increased Petrol and Diesel consumption and its emissions in relation to Alternate Fuels. Journal of Population Therapeutics and Clinical Pharmacology. 2023;30(11). doi:10.47750/jptcp.2023.30.11.013
65. T NRP, K NPJ. Energy Policy - Ethanol production in INDIA: The roles of policy, price and demand. International Journal of Advanced Research in Science Communication and Technology. May 2023:562-571. doi:10.48175/ijarsct-11140a.
66. Caperello ND, Kurani KS. Households' stories of their encounters with a Plug-In Hybrid electric vehicle. Environment and Behavior. 2011;44(4):493-508. doi:10.1177/0013916511402057.
67. Oliver HH, Gallagher KS, Tian D, Zhang J. China's fuel economy standards for passenger vehicles: Rationale, policy process, and impacts. Energy Policy. 2009;37(11):4720-4729. doi:10.1016/j.enpol.2009.06.026.
68. Rajendran G, Vaithilingam CA, Misron N, Naidu K, Ahmed MR. A comprehensive review on system architecture and international standards for electric vehicle charging stations. Journal of Energy Storage. 2021;42:103099. doi:10.1016/j.est.2021.103099.
69. Liu, Z. (2016). China's carbon emissions report 2016.
70. 70 She ZY, Sun NQ, Ma JJ, Xie BC. What are the barriers to widespread adoption of battery electric vehicles? A survey of public perception in Tianjin, China. Transport Policy. 2017;56:29-40. doi:10.1016/j.tranpol.2017.03.001.
71. Patyal VS, Kumar R, Kushwah S. Modeling barriers to the adoption of electric vehicles: An Indian perspective. Energy. 2021;237:121554. doi:10.1016/j.energy.2021.121554.
72. Adnan N, Nordin SM, Amini MH, Langove N. What make consumer sign up to PHEVs? Predicting Malaysian consumer behavior in adoption of PHEVs. Transportation Research Part a Policy and Practice. 2018;113:259-278. doi:10.1016/j.tra.2018.04.007