Exploring Mindfulness and Innovative Creative Development: Lessons Learnt using the Study of Electric Vehicles for Sustainable Development

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The concept of mindfulness has drawn considerable attention in everyday lives and life style. The concept emphasizes on being aware of the "moment" that one experiences by embracing the "here and now" approach. A shift has been observed in the behaviour of consumers towards mindful consumption. Mindfulness enables an individual to curb their urges and have a better control on their feelings and opinions. Mindfulness can lead to healthy life style which embraces the triple bottom line People Planet and profit and Electric Vehicles are one such Creative Innovation. The Focus of this paper is to throw light on Electric vehicles (EVs) a promising technology for achieving a sustainable transport sector in the future, due to their very low to zero carbon emissions, low noise, high efficiency, and flexibility in grid operation and integration. It offers a summary of the technologies used in electric vehicles, together with information on the corresponding energy storage technologies and charging infrastructure. Present are various electric-drive car models. Vehicles that run on electricity include fuel cell electric vehicles, battery electric vehicles, plug-in hybrid electric vehicles, and hybrid electric vehicles. There includes discussion of the enabling technologies as well as the topologies for each category. There are new battery technologies, various charger converter topologies, and numerous power train combinations introduced.

Keywords: Mindfulness, Electric Vehicles, Sustainable Development

New Car Assessment Programs (NCAPs) have subjected several petrol-electric hybrid vehicles to the 64km/h frontal offset crash test, 50km/h barrier side impact test and the 29km/h side pole test. No problems with the electrical systems or batteries were encountered. These tests have generally involved vehicles with lead-acid or NiMH batteries. Lithium-ion batteries are becoming popular and these might introduce different hazards for crash-test and rescue personnel.
The move to clean energy is facilitated by electrifying transportation, which also allows for the sector's fuel mix to be more diverse and addresses concerns about energy security. Additionally, this can be considered as a workable way to help with climate change-related problems. Additionally, the procedures and standards for charging are discussed, as well as the relative effects that charging vehicles have on the grid.

1. Introduction

There has been a global paradigm shift in how the future of vehicles will evolve. While flying cars may not be seen as a feasible option in 2022, we have come a long way from the traditional fuel-guzzling vehicles to alternatives such as EVs, both in two-wheeler and four-wheeler segments. While Indian sentiments are clearly more oriented towards two-wheelers which occupy almost 70% of road presence, this does not seem to be limiting the development of four-wheeler EVs. India is actively investing in and promoting a market which is predicted to hit over a 9 million units mark per annum by the year 2027. The need to shift to an alternative fuel can be attributed to rising fuel costs and adopting cleaner energy sources. Climate change is an increasingly relevant concern, with every major nation actively acknowledging the problem and looking at real time solutions, which provides a further impetus to the shift to EVs. The Indian automobile industry places heavy reliance on the use of traditional fossil fuels and non-renewable forms of energy which has raised concerns regarding its impact on the environment, climate change and the depletion of the non-renewable resources. To adopt a cleaner and more eco-friendly energy alternative, India has formulated policies to shift from traditional ICE vehicles to vehicles using alternate forms of energy, specifically EVs. Further, dependence on fuel imports and the consistently rising prices of conventional fuels have also prompted consumers to seek more cost-efficient sources of transportation. These initiatives for adoption of clean engines for both commercial and private vehicles have led to an increase in the number of manufacturers of EVs in the short and long-distance transportation and last mile connectivity arenas2. Mahindra & Mahindra, an Indian manufacturer of automobiles, plans to aggressively expand its range of EVs being offered in the Indian market and has planned for an investment of approximately USD 400 million whilst also looking at foreign investors3. TVS Motors, a two-wheeler manufacturer, is also in discussion with global private equity investors looking at investment of approximately USD 296 million to USD 493 million for business expansion into EVs through the launch of a new line of electric two-wheelers.

Key Findings

1. Ownership and Driving Experience:
- A significant portion of respondents (around 64%) had never personally owned an electric car.
- However, a majority of respondents (around 57%) had driven an electric car at least once.

2. Advantages of Electric Vehicles:
- The main benefits of electric vehicles highlighted by respondents were cost-friendliness, environmental friendliness, less maintenance, and freedom from rising petrol prices.
- Easy handling and usage were also mentioned as advantages by several participants.

3. Disadvantages of Electric Vehicles:
- Limited battery range was consistently cited as a main disadvantage by respondents.
- Concerns about battery life span and charging infrastructure were other frequently mentioned drawbacks.

4. Likelihood of Purchase:
- A diverse range of responses was observed in terms of purchase intent.
- While some respondents expressed a definite willingness to buy an electric vehicle (around 28%), others were unlikely to do so (around 26%).

5. Charging Preferences:
- The preferred charging time for respondents varied, with responses ranging from 10 minutes to several hours.

6. A sizable number of respondents (around 25%) indicated a preference for a charging time of 1 to 2 hours.

7. Expected Driving Range:
- The desired driving range on a fully charged battery varied widely, with preferences ranging from less than 20 km to more than 180 km.
- A common range preference was between 100 km and 130 km.

8. Image and Perception:
- A significant number of respondents (around 36%) believed that buying an electric vehicle would have a positive impact on their image.

9. Anticipated Shift to Electric Vehicles:
- Respondents had diverse opinions on when electric cars would comprise the majority of total vehicles owned.
- The majority were uncertain about the timeline for this transition.

10. Driving Habits:
- Respondents' daily driving habits varied, with some driving less than 20 km per day and others driving more than 180 km per day.

11. Demographic Trends:
- The survey participants comprised both males and females, with a slight gender skew towards females.
- The age distribution was relatively evenly spread, with a significant portion falling within the 20-25 years age group.
- Education levels varied, with a majority holding postgraduate or graduate degrees.

2. Literature

New entrants manufacture most EVs in the two-wheeler, three-wheeler, and bus segments. Several manufacturers have technology tie-ups with international players (Olestra Greentech has collaborated with BYD to roll out a 12-meter K9-electric bus), bringing investments and the latest technology into the country. These collaborations are aimed at setting up new factories, generating employment opportunities, and competing in existing markets with established OEMs. In terms of investments, the EV industry has attracted ~US$6 billion in 2021 and is expected to gain US$20 billion by 2030. Furthermore, it is estimated that if India reaches the government's target, it can become a manufacturing hub for EVs, subsequently driving the exports. On the employment front, the Ministry of Skill Development and Entrepreneurship has estimated that the EV industry can create one crore direct jobs and five crore indirect jobs by 2030. There is a significant scope for employment in the technological domains, such as artificial intelligence, analytics, and application development. The industry is likely to observe high recruitments in development and manufacturing, wherein it can also bring subject-matter expertise involving supply chain, operations, and consumer behaviour. Strong demand is expected for professionals skilled in electrical concepts. Furthermore, the government has also offered support through the National Skill Qualification Framework (NSQF), enabling channels to energize skilling and generate a resource pool for the EV industry. FUEL IMPORT India is ~85% reliant on imports to meet its crude-oil requirements. Being a large oil-importing economy, its oil imports amounted to US$119.2 billion in FY22, up from US$62.2 billion in FY21. This resulted in the current account deficit hitting a 3-year high of 1.8% (US$43.81 billion) in FY22. In the coming fiscals, crude oil demand is expected to grow 3%-4% annually, leading to a strong imperative shift from fuel-powered vehicles. This can present a strong opportunity for EVs to fill the void. They will also reduce India's oil dependency, decarbonize the mobility industry, and help it transition toward zero-emission models. According to the research study by Council on Energy, Environment and Water (CEEW), if the share of EVs increases to 30% by 2030, India could save up to US$14 billion on its oil import bill.

EV Technology

Vehicle Components and Technical Difference In Ice Vs. EV

The fundamental component in an EV is a high voltage battery (occupying 40% of the cost of production). The battery is responsible for providing sufficient energy to the electric motor and is placed on the floor or in the boot. The electric motor is another essential component of EVs, responsible for converting electrical energy into mechanical energy and propelling the vehicle to move. Almost all EVs are equipped with automatic transmission (direct drive), reducing the need for transmission fluid and lower power loss to the wheels. The power train is the differentiating system between ICE and EV. Power trains for ICEs are complex compared to EVs, with hundreds of parts, including differentials, axles, emission controls, exhausts, and engine cooling systems. EV powertrains have a relatively simpler structure compared to ICE power trains and only include battery packs, charging ports and drive train units. TOTAL COST OF OWNERSHIP (TCO) AND ITS EVOLUTION: Currently, there is a strong imparity in Capex for EV and ICE variants, with an electric car costing ~2x of an ICE variant. Similarly, the cost of e-buses is ~1.5-2x higher than the diesel counterparts, subject to specifications. Strong government support (from central and state governments) in the form of subsidies has helped E2W and E3W achieve price parity with their ICE counterparts. However, OEMs are struggling to achieve price parity for E4W and buses, owing to the inflationary impact driving the input prices. Additionally, the EV industry is heavily import-driven pertaining to Li-ion battery cells, and the high inflation rate in India has deteriorated the USD/INR, making it difficult for importers to procure cells at a lower cost. With this, India must develop indigenous battery supply chains to achieve price parity for E4W and e-buses. Furthermore, the EV industry needs economies of scale to be resilient to the frequent input price shocks. High demand subsidies under the Faster Adoption and Manufacturing of Hybrid and EV (FAME II) scheme coupled with the emergence of the battery-as-a-service (BaaS) model are likely to reduce the total cost of operation (TCO) of EVs in coming years.

Segment-Wise EV Registration

Electric 2-wheelers (e2W)

Sales of e2Ws have gained traction in the last two years, going from ~27,000 to over 143,000, a growth of ~425% over 2020. The spike can be attributed to the need for personal mobility, increased environmental awareness and a rise in gasoline prices (increased by INR43(~46%) from 2019 to 2022). The second phase of Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME II) incentives have also helped in the increased adoption of e2W. The first quarter of 2022 has already seen sales of almost 110,000 units.

Electric 3-Wheelers (e3W Auto)

Electric 3-wheelers: Apart from e2W, the electric 3-wheeler (e3W) auto market (which includes the cargo and passenger segments but excludes e-rickshaws) has seen a significant increase in patronage. Most of the sales are coming from the goods segment, as companies use e-autos for last-mile delivery. Their total cost of operation per km is lower than the conventional IC engine autos' by ~55%. In addition to that, increase in e-commerce sales and easy switch ability from ICE due to fixed load cycles (groceries) are helping drive sales. Passenger autos are still ICE based, as their load cycles are not regular, and range anxiety remains a hurdle. The projected numbers do not include E-rickshaws and e-carts, which are estimated to reach ~850,000 units by the year 2027.

Electric 4-Wheelers (e4W)
Electric four-wheelers (e4W) sales gained momentum in 2021 (after the pandemic) due to higher gasoline prices and the growing need for personal mobility. However, it is still in the early stages, and ICE cars are dominating the market. Several factors are contributing to this scenario. Most households have only one car. Moreover, e4W doesn't have the range needed for inter-city commute (not fixed load cycles), and the price difference between ICE and EVs is significant. However, we expect a ~200% increase in sales in 2022 compared to 2021.

Electric Buses
Fleet electrification is a fledgling segment. There are fewer e-buses than ICE ones, and the penetration is also low. Limited models from OEMs, range anxiety, varying duty cycles, and high initial procurement costs prevent the segment from growing. However, e-buses with improved efficiency are a high priority for several state governments aiming to decarbonize public transport and retire over-aged buses. More traction in this segment is expected over the next five years.

Charging Infrastructure
The lack of charging infrastructure is one of the biggest challenges for the EV sector. Currently, there are only 1,742 charging stations in the country. This number is expected to increase to 100,000 units by 2027 to accommodate the increasing demand by ~1.4 million EVs expected to be on the roads by then. An adequate presence of charging points, especially for fast charging, can tip the scales in Favor of EVs, especially as cars and two to four- wheelers are expected to be used for long-distance transport. Currently, the limited presence of charging points means customers cannot opt for quick top-ups or charging their vehicles in emergencies.

Barriers to EV Adoption in India
While it cannot be denied that EVs provide huge benefits over traditional vehicles that use fossil fuels, there are several challenges that need to be addressed to realise the full potential of EVs in India. The major issues present in the EV space are summarised below:

Charging Infrastructure
One of the major hurdles in adoption of EVs in India is the unavailability and slow development of charging infrastructure. Charging infrastructure is the foundation on which the EV market is built and India has not achieved an expeditious pace of establishment and use of charging infrastructure which creates a barrier in both production and sale of EVs in India. Factors like unsurety in utilization rates of charging stations, huge operating costs, load on electricity DISCOMs, etc., create a negative environment for operators to establish charging stations and discourage investment when there are not sufficient number of EVs in Indian roads for operators to realise the returns on their investments.

However, as discussed above, Indian policymakers are taking steps to address the lack of charging infrastructure and providing legal regulatory support for setting up of charging infrastructure for EVs. A smart, low cost, AC charge point has been developed by the DST and the office of the PSA to the Government of India with NITI Aayog for light EVs (e-scooter and e-autorickshaws) which may be installed in metros, railways, parking spaces, shopping malls, offices, residential areas which will give a much-needed push for EVs. Since this low-cost AC charge point requires lower investment the dependence on subsidiaries and concessions from the government can also be reduced.

Batteries used in EVS
EVs use lithium-ion batteries that require the use of metals like lithium, magnesium, cobalt, nickel, etc. This means that to successfully incorporate EVs as mainstream vehicles adequate resources of these metals are required to manufacture the batteries used in EVs. For countries deficient in these resources, manufacture of EVs become dependent on availability of the same mainly through imports which increases the cost of procurement of raw materials and manufacturing of EVs. In the financial year 2019-2020, India imported approximately 450 million units of lithium-ion batteries at a cost of approx. USD 865 million. Lithium-ion batteries also have a huge environmental impact. Lithium extraction requires a huge amount of water, harms the soil, and contaminates the air. In addition, recycling of lithium-ion batteries is also not efficient since they degrade over time and cannot be used as new batteries.

However, alternatives to lithium-ion batteries are being developed by major manufacturers in the automobile industry. A prime contender of replacement of lithium-ion batteries is a dual carbon battery which is both less toxic and cheaper than lithium- ion batteries. Research is well underway to intensify the energy density of such batteries. Another way forward is the use of aluminium-air batteries to shift reliance to bauxite and aluminium from lithium which is of limited availability in the country.

3. Research and development

India still falls behind on strong R&D capability and consequently, manufacturers rely mostly on technological know-how borrowed from their foreign counterparts for EV components. Main research areas related to EV components are the constituents of the cells of lithium-ion batteries since these constitute the most expensive components requiring significant research in these areas. Research is required to be undertaken on high priority on EV components to make way for affordable

and efficient adoption of EVs. However, this scenario is also changing, and the ARAI has been leading research on EVs and fast charging technologies as per the requirements of the Indian market.

Pollution

Compared to traditional vehicles that burn fossil fuel for energy, EVs are a cleaner, greener and better alternative in curbing depletion of natural resources and greenhouse gas emissions from the automobile industry. However, it cannot be denied that manufacture and use of Evs also contribute to environmental degradation. A major reason for pollution attributable to Evs is the use of traditional fossil fuels like coal to generate electricity for charging infrastructure. Establishment and operations of charging stations depend largely on the thermal power plants that further contribute to pollution. Therefore, it is important that the source of power generation for charging infrastructure be cleaner alternatives like solar or wind or hybrid power plants since using traditional power generating methods may defeat the main purpose of adoption of Evs.

As discussed above, extraction of metals for manufacture of lithium-ion batteries also causes contamination of soil and air and require huge amount of water. Disposal of batteries of Evs also is an arena of concern. Only a small number of batteries are recycled and most batteries end up in garbage dumps or are used for extraction of metals through other unclean technologies. From a legal perspective, the Batteries (Management and Handling) Rules, 2001 does provide for a mechanism for handling and disposal of lead-acid batteries, however these rules do not cover lithium-ion batteries used in Evs. The Ministry of Environment, Forest and Climate Change have published the draft Battery Waste Management Rules, 2020 for suggestions from the public which defines 'battery' to include lead acid/lithium ion/lithium metal/nickel cadmium batteries. The draft Battery Waste Management Rules, 2020 lays down detailed provisions on the responsibilities of the manufacturers, producers, dealers, recyclers, consumers, state pollution control board/pollution control committee and other stakeholders for collection, labelling, disposal and handling of batteries, including establishment of collection centres, which will provide a much-needed ecosystem to curb pollution attributable to lithium-ion batteries used in Evs.

Consumer Attitude

Cost effectiveness is one of the major factors an Indian customer considers before making their choice and if the EV market cannot showcase cost benefit and optimum utilization, it might fail to attract the attention of Indian customers. Various levels of the Indian government have attempted to provide cost incentives to EV consumers that addresses the issue in a limited manner. However, barriers like absence of sufficient charging infrastructure, cost for repetitive battery replacement, etc., do not make EVs a popular option for the Indian consumers. Further, in the absence of widespread marketing strategies concerning the impact and importance of EVs, Indian consumers have limited awareness of EVs as alternative to traditional fossil fuel engine-based vehicles.

Despite the above, there has been an influence of global trends on Indian consumers resulting in an upward shift in consumer preference toward EVs. Global brand like Tesla, an American manufacturer of EVs, has earned world recognition in making cost effective and energy efficient EVs which have become world renowned. The worldwide adoption and use of EVs along with awareness of the importance of climate change has slowly instilled the consumer's confidence in EVs in the Indian market. Another factor that has influenced the attitude of the Indian consumer towards EVs is the introduction of e-rickshaws which has replaced traditional rickshaws in the public transportation sector due to their cost, energy efficiency and cheaper maintenance. This has also contributed to the Indian market feeling familiarised with EVs and willing to adopt EVs over traditional engine-based vehicles. Therefore, evolving consumer trends can contribute to make the EV market in India grow exponentially. Incentives and subsidies offered by the government also go a long way to facilitate widespread adoption of EVs by Indian consumers.

The resolution of the aforementioned barriers may be undertaken through serious intervention by the government at various levels, ownership of EV infrastructure at high levels, fast decision making, collaboration and coordination with different stakeholders in the EV space and serious commitment to short- and long-term goals is required to ensure faster adoption of EVs in India.

4. Research Methodology

Methodology

This section outlines the research methodology adopted for the Electric Vehicles (EVs) market analysis project. The research strategy is elaborated upon, followed by the research design that guides the study's structure. Primary data collection techniques are then described, involving a combination of benchmarking, surveys, and semi-structured interviews tailored to the EV industry. Additionally, secondary data collection methods are discussed, encompassing the utilization of existing relevant data sources. The section concludes by addressing the study's quality assessment, covering both the qualitative and quantitative research aspects specific to the EV market research context.

Research Strategy

In the context of the Electric Vehicles (EVs) market research project, a comprehensive research strategy is outlined to effectively explore various aspects of the EV industry. The project's primary objective is to analyse the current landscape of electric vehicles and gather insights into consumer preferences and demands. To achieve this, a mixed-method approach involving both primary and secondary data collection methods is employed.

Mixed Method Approach

The primary goal of this EV market research is to understand consumer perceptions and preferences concerning electric vehicles. To achieve this, a combination of qualitative and quantitative research strategies is employed, allowing for a deeper and more comprehensive exploration of the research questions. Unlike the typical application of mixed methods in tandem, these strategies are thoughtfully integrated to provide a holistic understanding.

Primary Data Collection Structure

The research commences by delving into qualitative insights through semi-structured interviews with key stakeholders in the EV industry. These interviews aim to capture intricate details and nuances of the electric vehicle market. Considering the dynamic and evolving nature of the EV market, the semi-structured interviews offer a suitable approach to glean insights effectively.

The information obtained from the semi-structured interviews serves a dual purpose. Firstly, it aids in building a solid foundation of understanding about the EV market, enabling the crafting of targeted and relevant questions for the subsequent quantitative research phase. This approach ensures that the survey questions are aligned with the insights derived from the qualitative interviews.

The quantitative phase involves conducting a survey, chosen for its ability to reach a wide audience and capture quantitative data efficiently. The survey is constructed based on the insights obtained from the semi-structured interviews, ensuring that it addresses key aspects identified during the qualitative phase. By strategically tailoring the survey to reflect the qualitative findings, the research aims to collect quantitative data that is both relevant and insightful.

In addition to the primary data collection, secondary data sources are tapped into to supplement and validate the primary findings. This involves gathering existing data related to the electric vehicle industry, including market trends, sales statistics, technological advancements, and consumer behavior patterns. This secondary data serves as a valuable reference point to corroborate and enrich the primary research findings.

In summary, the mixed-method approach, combining qualitative insights from semi-structured interviews and quantitative data from surveys, forms the core of this research strategy. The integration of these strategies, informed by the findings from primary and secondary data sources, provides a well-rounded understanding of the Electric Vehicles market, its consumer preferences, and its growth trajectory.

Primary Data Collection

Preparing for Primary Data Collection

To initiate the primary data collection phase for this Electric Vehicles (EVs) market research project, a comprehensive preparation process was undertaken. Prior to commencing primary data collection efforts, the research team participated in an introduction day hosted by a prominent player in the EV industry. This introductory session took place at a significant location within the EV landscape. During this event, a comprehensive overview of the EV market and its dynamics was presented. The session also facilitated an introduction to key individuals within the EV domain who would play a crucial role in the upcoming semi-structured interviews.

The primary intention behind this introduction day was to provide the research team with an initial insight into the EV market, particularly focusing on its current landscape and prevailing trends. This insight, gleaned from the introduction day, laid the groundwork for the subsequent primary data collection phase. However, it's important to note that the information obtained during this introductory session was not classified as primary data but rather served as a foundational understanding to guide the forthcoming semi-structured interviews.

As the core aim of the project is to comprehensively understand the EV market and its various facets, the introduction day played a pivotal role in framing the subsequent data collection process. The information gathered during this session formed a basis for more in-depth inquiries during the semi-structured interviews, ensuring that the subsequent primary data collection was aligned with the foundational understanding obtained during the introduction day.

In essence, the preparation for primary data collection involved a strategic introduction day that furnished the research team with valuable insights into the EV industry. These insights subsequently informed the semi-structured interview approach, thus contributing to a holistic understanding of the Electric Vehicles market and its various dimensions.

Structure of Primary Data Collection

Following the enlightening introduction day within the realm of the Electric Vehicles (EVs) market, a well-defined and interconnected structure was employed for primary data collection. This structure encompasses three distinct primary data collection methods, all meticulously tailored to provide comprehensive insights into the diverse facets of the EV industry. The synergy between these methods facilitates a holistic understanding of the EV landscape.

Self-Completion Survey: The third and final primary data collection method revolved around a self-completion survey. This survey aimed to address the first and third Research Questions, shedding light on consumer perceptions and preferences within the EV market. The insights extracted from the semi-structured interviews provided a foundation for crafting survey questions that effectively encapsulate the qualitative insights.

Survey

Purpose of the Survey

A survey serves as a vital instrument in capturing insights into the landscape of Electric Vehicles (EVs) and the broader market dynamics. The primary aim of this survey is to elucidate the prevailing trends, perceptions, and considerations within the realm of electric cars. The survey method allows for a quantitative exploration of key aspects, shedding light on factors that influence the acceptance and adoption of electric vehicles.

The survey comprises a series of questions designed to gather a comprehensive perspective on individual experiences and opinions concerning electric cars. Respondents are asked about personal ownership and driving experiences with electric vehicles, helping gauge familiarity and exposure to the technology. The survey also delves into the perceived advantages and disadvantages of electric vehicles, providing valuable insights into consumer perceptions of the technology's strengths and limitations.

Furthermore, the survey probes respondents' future intentions regarding electric vehicle adoption. By inquiring about the likelihood of purchasing an electric vehicle within the next two years, the survey seeks to uncover potential shifts in consumer preferences over a defined time frame. Respondents' expectations regarding charging time and battery range contribute to understanding the key considerations that influence their decision-making process.

The survey also captures respondents' projections about the future prevalence of electric cars in the market, offering a glimpse into the anticipated rate of adoption. Additionally, the survey includes questions related to respondents' daily driving habits, aiming to establish a correlation between driving patterns and potential electric vehicle adoption.

Opinions on the cost-saving potential of electric vehicles, their capability to replace traditional gas-powered vehicles, and the perceived impact on personal image are also explored. By querying respondents on these dimensions, the survey uncovers prevailing attitudes that contribute to the broader perception of electric cars.

In summary, the survey methodology is strategically designed to gather quantitative insights into the EV landscape. It captures a diverse range of perspectives, providing a foundation for understanding consumer sentiments, preferences, and intentions in the context of electric vehicles. The survey's holistic approach contributes to the project's overarching goal of comprehensively analysing the electric vehicle market.

Survey Setup

The survey's design and setup were strategically crafted to gather insights effectively while ensuring respondent convenience and engagement. To facilitate the survey process, Google Forms, a user-friendly tool known for its ease of use, was employed (Google Forms, 2023). Leveraging the authors' prior experience with this tool expedited the survey creation process, enabling a seamless development process that maintained a focus on accuracy and relevance.

To optimize respondents' engagement and streamline their experience, a respondent-friendly approach was adopted. A dynamic navigation feature was integrated, guiding respondents to relevant questions and automatically bypassing irrelevant ones. This approach was selected as it acknowledges that certain questions may not apply universally. For instance, respondents without personal vehicle ownership need not respond to queries about monthly car expenditures. This tailored navigation minimizes respondent burden, ensuring a smoother survey experience.

A visual progress bar was thoughtfully incorporated to indicate the completion status of the survey. This not only assists respondents in gauging their progress but also fosters motivation to complete the survey. Furthermore, the survey was structured with clear section divisions, using distinct headlines to guide respondents through different thematic segments.

In addition to the interactive setup, introductory and concluding texts were included. An initial brief about the context of electric vehicles and the purpose of the survey was provided to contextualize the survey. A gracious closing note expressed gratitude to the respondents for their valuable participation, conveying the authors' appreciation for their time and insights.

A notable benefit of questionnaires is the ease of comparison among responses due to the predefined nature of the questions.

Notably, certain questions in the survey requested respondents to rank statements based on their level of agreement. The ranking scale was designed to encompass a range of responses, as shown in Table 5, providing nuanced insights into the degree of agreement.

Table 5 Explanation of the Ranking Scale

1. Strongly disagree
2. Disagree
3. Neither disagree nor agree
4. Agree
5. Strongly agree

In essence, the survey's meticulous setup optimizes both respondent convenience and data collection efficiency, ensuring a well-structured and engaging approach to capturing insights into the electric vehicle landscape and market dynamics.

Publication of Survey

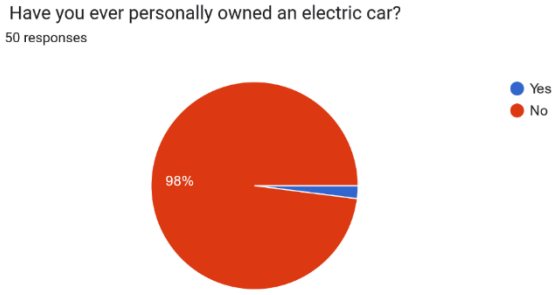
The refined survey was unveiled to the public via WhatsApp. Members collaborated to disseminate the survey, aiming for maximum visibility within their respective networks. The initiative reached an estimated audience. Recognizing the potential for broader engagement, a reminder was dispatched 24 hours later. This strategic reminder was designed to prompt individuals who had not yet participated and to ensure wider coverage by reaching individuals who may have missed the initial postings.

The decision to employ the audience WhatsApp groups for survey distribution was rooted in insights gleaned from the project's objectives. These insights highlighted the importance of engaging audiences intrigued by innovative vehicle ownership models. By focusing on these platforms, the survey aimed to tap into a diverse range of respondents who resonate with forward-thinking concepts.

The selected distribution approach effectively harnessed the power of digital platforms and targeted outreach, underscoring its alignment with the project's aspirations. This approach was attuned to the diverse landscape of the electric vehicle market and succeeded in achieving meaningful engagement from respondents within the specified timeframe.

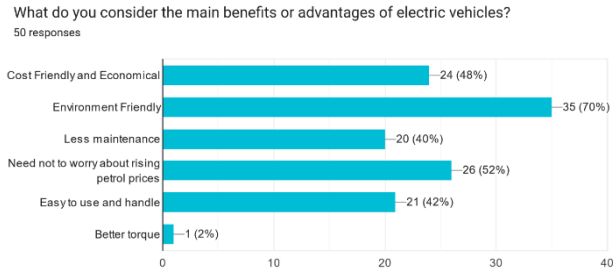
Data Interpretation

1. Have you ever Personally Owned An Electric Car?



98% of the people responded, as saying that they never owned an electric car.

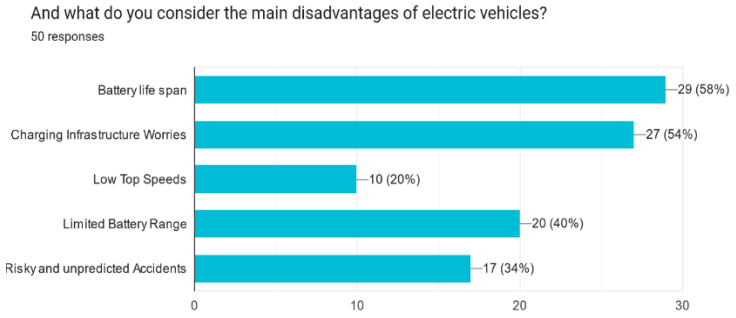
2. What do you Consider the main Benefits or Advantages of Electric Vehicles?



The main advantage with owning an electric vehicle has been attributed to them being environment friendly. The graph shows the percentage of people who are interested in using an electric vehicle (EV) based on four factors: cost-friendliness, environmental friendliness, less maintenance, and easy to use and handle.

- **Cost-friendliness:** 48% of people are interested in using an EV because it is cost-friendly. This is likely due to the fact that the operating costs of an EV are lower than those of a gasoline-powered car.
- **Environmental friendliness:** 70% of people are interested in using an EV because it is environmentally friendly. This is likely due to the fact that EVs produce zero emissions, which can help to improve air quality.
- **Less maintenance:** 52% of people are interested in using an EV because it requires less maintenance than a gasoline-powered car. This is because EVs have fewer moving parts, which means there is less that can go wrong.
- **Easy to use and handle:** 42% of people are interested in using an EV because it is easy to use and handle. This is likely due to the fact that EVs have a simpler design than gasoline-powered cars, which makes them easier to operate.

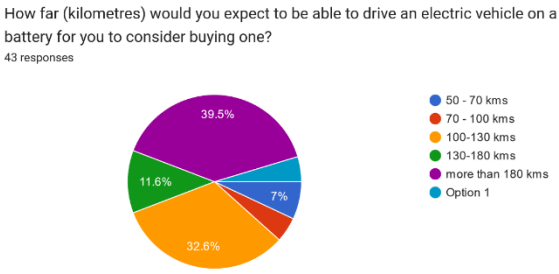
3. And what do you consider the main disadvantages of electric vehicles?



Maximum number of respondents believed that the main disadvantage associated with electric vehicles is their battery life span. The image shows a graph of the average lifespan of batteries for different types of batteries. The average lifespan of a battery is 20 hours, while the average lifespan of a limited battery range is 10 hours. The average lifespan of a limited battery range electric vehicle is 20 hours.
The image also shows the following text

- **Grid infrastructure worries:** 29% of respondents are worried about the grid infrastructure being able to support the widespread adoption of electric vehicles.
- **Low top speeds:** 10% of respondents are concerned about the low top speeds of electric vehicles.
- **Limited battery range:** 20% of respondents are concerned about the limited battery range of electric vehicles.
- **Unpredicted accidents:** 17% of respondents are concerned about the risk of unpredicted accidents involving electric vehicles.

4. How far (kilometres) would you expect to be able to drive an electric vehicle on a fully charged battery for you to consider buying one?



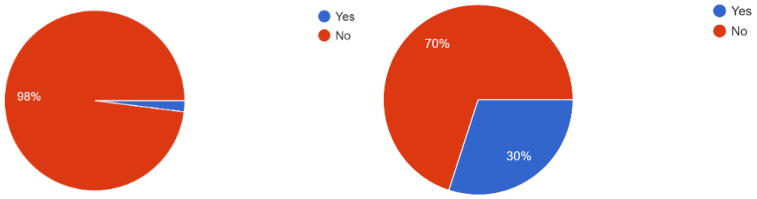
The pie chart you sent me does not show the percentage of people driving. It shows the percentage of people who live within different distances from their workplace. The largest percentage, 39.5%, live within 50-70 kilometres of their workplace. 11.6% live within 70-100 kilometres, 32.6% live within 100-130 kilometres, and 7% live more than 180 kilometres from their workplace.

The pie chart does not say anything about the percentage of people who drive. It is possible that some people who live within 50-70 kilometres of their workplace do not drive, and some people who live more than 180 kilometres from their workplace do drive. The pie chart only shows the distance between people's homes and their workplaces.

I hope this analysis is helpful. Let me know if you have any other questions

Analysis of Data

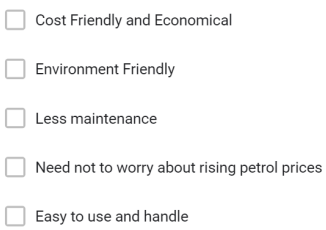
We considered a sample of 50 individuals for the study.



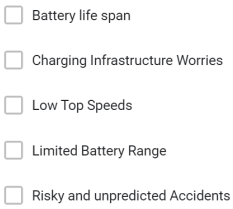
Out of a sample of 50, only 2% have owned an electric vehicle (EV), and out of these only 30% have actually driven the vehicle.

Out of these advantages, the most beneficial according to the sampling individuals is that electric vehicles are environment friendly.

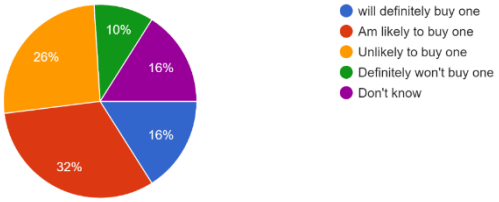
The next best advantage is that we do not have to worry about the rising petrol prices.



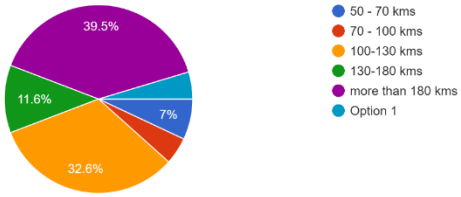
The biggest disadvantage of an electric vehicle is the battery life span. It is the biggest concern with the charging infrastructure.



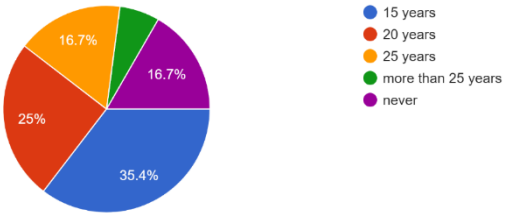
With all the advantages and disadvantages of an electric vehicle, only 32% are likely to purchase an EV. And 16% are sure of buying one.



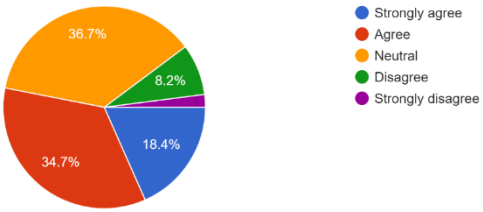
For people to buy the EV, their criteria for majority of people are that it should be charged within 2hours.
The EV should work for at least >180 kms per charge for them to consider buying it. 32% have the requirement as 100-130.



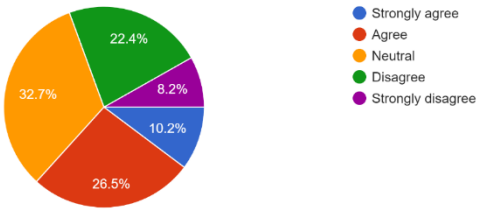
The speculation of sample is that it will take a minimum of 15 years for EVs to become a majority.



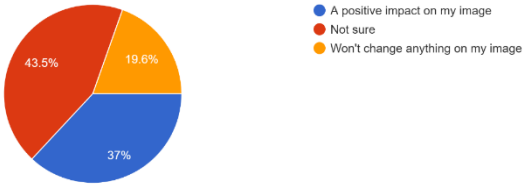
The general opinion of the sample is that EV's can save money for car buys.



When it comes to whether or not EVs can fully replace gas vehicles, the sample results are inconclusive. It is because around same percentage of marks are given to 'agree', 'disagree' and neutral.



Majority of sample are not sure as to what effect the purchase of EV will be on their image, positive or negative.



All in all, the analysis of attitudes towards electric vehicles reveals that people have mixed views towards their acceptance. People are still hesitant when it comes to shifting to electric vehicles from standard petrol, diesel or CNG vehicles. Also, not all have access to EVs. Hence there is no trial induced nor there is awareness about it. The knowledge of people about EVs is limited.

5. Findings

The conducted survey yielded valuable insights into participants' perceptions and inclinations towards electric vehicles (EVs). Respondents widely acknowledged the advantages associated with EVs, with a substantial portion recognizing their cost-effectiveness, environmental benefits, and reduced maintenance requirements. However, concerns were apparent, particularly regarding battery lifespan and the adequacy of charging infrastructure. The data collected from the 53 respondents offer valuable insights into the factors influencing the adoption and acceptance of EVs in today's automotive landscape.

One of the most notable trends that emerged from the findings was the widespread recognition of the advantages associated with electric vehicles. A significant proportion of participants, 49.1%, identified cost-friendliness and economic benefits as a primary advantage. This highlights the growing awareness among consumers of the potential long-term savings that EVs offer, particularly in terms of reduced fuel costs and maintenance requirements. Additionally, 69.8% of respondents emphasized the environmental friendliness of EVs, showcasing the increasing importance of sustainable transportation solutions in the face of climate change.

While the advantages garnered substantial support, the survey also shed light on the concerns and disadvantages that potential EV buyers consider. Battery lifespan and charging infrastructure worries emerged as prominent factors, with 56.6% of participants expressing these as key disadvantages. This underscores the critical role that infrastructure development and advancements in battery technology play in boosting the adoption of EVs. Moreover, the limited battery range was cited as a concern by 41.5% of respondents, indicating the need for continued efforts to enhance the driving range of EVs to meet consumers' expectations and demands.

The data regarding participants' likelihood of purchasing an EV in the next two years revealed a promising inclination towards electric mobility. A combined 30.2% of respondents expressed their intent to consider buying an EV, with 15.1% indicating a definite willingness. This positive outlook suggests a growing interest in embracing EVs, potentially driven by the increased availability of models and improvements in charging infrastructure.

Interestingly, the findings also highlighted the diversity in expectations when it comes to charging times and battery range. Participants' preferences ranged from as short as 10 minutes to as long as 8 hours for a full charge, and the desired battery range varied widely from 50 to over 180 kilometers. These divergent preferences underscore the need for manufacturers to offer a range of options that cater to different user profiles and usage patterns.

The survey findings underscore a growing awareness and interest in electric vehicles among consumers. The recognition of their benefits, coupled with concerns about battery lifespan and charging infrastructure, indicates a dynamic landscape in which advancements in technology and infrastructure development will play a pivotal role in shaping the future of transportation. As the automotive industry moves towards electrification, understanding these trends and preferences is crucial for stakeholders to effectively address consumers' needs and contribute to a sustainable future.

6. Conclusion

The survey on electric vehicles provides valuable insights into the perceptions and intentions of individuals regarding electric cars. Respondents highlighted the benefits of EVs, including cost and environmental friendliness, but also expressed concerns about battery-related limitations and charging infrastructure. The mindfulness and willingness to consider purchasing an EV varied, with factors such as charging time and driving range playing a crucial role. These findings demonstrate the complex interplay of factors influencing consumers' decisions to embrace electric vehicles. The insights from this survey can be useful for manufacturers, policymakers, and stakeholders in the electric vehicle industry to better understand consumer preferences and be mindful to tailor their strategies accordingly.

Gratitude and mindfulness for mother earth should be as regular as our heart beats. EV’s are a step towards this gratitude.

7. Bibliography

1. https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/topics/automotive-and-transportation/2022/ey-electrifying-indian-mobility-report.pdf

2. https://www.iea.org/energy-system/transport/electric-vehicles
3. **U.S. Bureau of Labor Statistics**- Charging into the future: the transition to electric vehicles- By Javier Colato and Lindsey Ice
4. https://www.bls.gov/opub/btn/volume-12/charging-into-the-future-the-transition-to-electric-vehicles.htm
5. The AFDC is a resource of the U.S. Department of Energy's Vehicle Technologies Office.
6. https://afdc.energy.gov/fuels/electricity_benefits.html
7. SAFETY PRECAUTIONS AND ASSESSMENTS FOR CRASHES INVOLVING ELECTRIC VEHICLES
8. **Michael Paine & David Paine**, Australasian NCAP, Australia; **James Ellway,** Euro NCAP, Belgium; **Craig Newland**, Australian Automobile Association, Australia; **Stuart Worden**, New Zealand Land Transport, New Zealand
9. https://www-esv.nhtsa.dot.gov/Proceedings/22/files/22ESV-000107.pdf
10. Noah Kittner & Daniel M. Kammen, in Technological Learning in the Transition to a Low-Carbon Energy System, 2020
11. https://www.sciencedirect.com/topics/social-sciences/electric-vehicles
12. Krishnamachar Prasad, Auckland University of Technology; January 2017 International Journal of Electric and Hybrid Vehicles 9(1):49 DOI:10.1504/IJEHV.2017.10003709
13. https://www.researchgate.net/publication/314306141_The_electric_vehicle_a_review
14. Bryman, A. and Bell, E. (2011) Business Research Methods. 3rd Edition, Oxford University Press, Oxford.https://www.qualtrics.com/experience-management/research/market-research-questions/
15. Narayanaswamy Vasantha Raju, Govt. First Grade College, Talakadu; January 2016; Conference: National Conference on "Scientific, Computational & Information Research Trends in Engineering, GSSS-IETW, Mysore
16. https://www.researchgate.net/publication/326831738_Online_survey_tools_A_case_study_of_Google_Forms
17. https://www.marketsandmarkets.com/Market-Reports/electric-vehicle-market-209371461.html
18. Author(s): AK shay J , Sonia M ; Jan 2022
19. https://www.alliedmarketresearch.com/electric-vehicle-market