PREPARED BY

Team of Electric Mobility Lab & MS (R)2021-2022

Electric Mobility Lab

Department of Electronics and Electrical Engineering
Indian Institute of Technology Guwahati
Assam, India, 781039
https://www.iitg.ac.in/e_mobility/
praveen_kumar@iitg.ac.in

Survey Report

"Accessibility of Electric Vehicle in Indian Market"

November 2021

- The Demographics of Population
- Electric Vehicle Ownership Scenario
- Price Band Expectations for EV deployment
- Factors Contemplating EV procurement
- Factors Downcasting EV procurement
- Road-Blocks in EV Adaption
- Expectations from public
- Awareness Check
- Insights
- Conclusions

Accessibility of Electric Vehicle in Indian Market

Author: Dr.-Ing. Praveen Kumar

International Standard Book Number (ISBN): 978-93-5578-243-4

Published by:

Dr.-Ing Praveen Kumar
E-54, IITG Campus,
Indian Institute of Technology, Guwahati,
Guwahati-781039,
Assam, India.
Phone: +91-9678000385
Email: praveen_kumar@iitg.ac.in
Website: www.iitg.ac.in/e_mobility/

Printed at:

Indian Institute of Technology, Guwahati,
Guwahati-781039,
Assam, India.
Phone: +91-361-2584000
Email: peeroff@iitg.ac.in
Website: www.iitg.ac.in/e_mobility/

Contents

1 Introduction

The electric vehicles (EVs) and transport electrification are accruing attention from various stakeholders in the transportation sector. The paradigm shift from the conventional internal combustion engine-based vehicles to battery-powered or electric powertrain based vehicles have been because of the rise in concerns for climate change and deteriorating air quality contemplated by organisations and government worldwide. Although the goal of net-zero emissions worldwide requires changes in the generation of power as well, yet transport electrification can be a significant boost.

India being among a few G20 countries working to meet the United Nations Framework Convention on Climate Change and Paris Agreement goals, is not far behind in taking decisive actions to meet the target of net-zero emissions. In the recent 26th Conference of Parties (CoP26), India declared its fivefold strategy titled "Panchamitra". The fivefold approach is:

1. India will **achieve a non-fossil fuel-based energy generation capacity to 500 gigawatts (GW) by 2030**.
2. India will **meet 50 % of its energy requirements from renewable energy by 2030**.
3. India will **reduce the total projected carbon emissions to 1 billion tonnes by 2030**.
4. India will **reduce the carbon intensity of its economy to less than 45 % by 2030**.
5. India will achieve the **target of net zero emissions by 2070**.

India is one of the world largest automotive markets considering the sales per year. The yearly sales of vehicles range from 21 million to 27 million vehicles. Although these sales are dominated by two-wheelers (80%), yet the sales volume is huge, indicating the paramount role of transport electrification in reducing emissions. Think tanks and policymakers are working on frameworks to ensure smoother transitioning from ICE to EVs. Recent developments by the governments agencies such as the think-tank NITI Aayog framed Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME-II) and other policies to push EV sales penetration. This penetration is expected to provide thrust to push sales of all segments of vehicles viz. private cars (30%), commercial cars (70%), buses (40%) and two-wheelers (2Ws) and three-wheelers (3Ws) (80%) by 2030.

The "Acceptability of Electric Vehicles in Indian Market" reports the public's view and expectations towards electric mobility in the current scenario when there is a rapid shift towards greener mobility.

This survey ***aims to understand the actual demands of the consumer so that we can bridge the gap between consumer expectations and the***

products developed by OEMs. The E-Mobility team of the Indian Institute of Technology Guwahati conducted an extensive survey in August and September 2021 and interviewed around ***1700 participants***. The participants were from rural and urban areas, from diverse professions, and with different educational qualification.

The survey's key finding is the ***willingness of over 70% of the participants to buy an EV in the next five years***. The overwhelming willingness shows the positive sentiment in the public towards EVs. It is necessary to address the issues of lack of charging infrastructure, price and range anxiety to convert this positive sentiment into actual adoption of EVs.

The survey also ***forefronts the challenges of the lack of awareness among people about electric vehicles***. This calls for extensive campaigns to generate awareness among the stakeholders regarding EVs through advertisements on media, door to door campaigns, and societal gatherings. The campaigns should be aimed at propagating the needs of stakeholders at the user end to the stakeholders involved in the business and manufacturing of the EVs. The challenge can be further dealt with by encouraging the design of dealership engagement programs in which people are trained and certified to sell EVs, resulting in better customer satisfaction as the people buying this technology will be utterly aware of what they were buying in the first place.

The findings of the survey also show a ***contrast between the expectations of the urban and rural populations***. The rural population has shown a higher inclination towards EV adoption compared to the urban. This is in sharp contrast to the EV OEMs, which are concerned with the urban-centric population. Since rural populations are expected to become a larger market of EVs soon, there is a need to expand the focus of EV manufacturers towards developing technologies that may serve both- urban and rural populations' requirements.

2 Acknowledgement

We take the privilege to thank the institute- **Indian Institute of Technology Guwahati** for providing us with the services that helped in completing the planned methodology for the survey and its disbursal.

We would further extend our thanks to the **people who participated in the survey and provided inputs to the variety of questions being asked.** The data presented in the report are an outcome of their sincere contribution to the survey.

We take this opportunity to express profound gratitude to **Dr Shareka Iqbal**, Assistant Professor, Department of Design, Indian Institute of Technology, Guwahati and **Mrs Purabi Das Kalita**. Their help in ensuring a wider reach of the survey forms to a variety of individuals is appreciated.

The report is an output of contributions made by individuals of varied backgrounds. **We want to thank every individual who was voluntarily involved in various phases of the report.**

Dr. Shareka Iqbal

Mrs. Purabi Das Kalita

3 The Authors and the Contributors

The **E-Mobility team from the Department of Electrical and Electronics Engineering** prepared this report on behalf of the Indian Institute of Technology Guwahati to **bring forward the gap of electric vehicles' customer expectations and demands**. Further, the report is **expected to gauge the pulse of the country and the readiness of the population for the adoption of EVs in the near future**. The E-Mobility team, led by Dr.-Ing. Praveen Kumar, who is a professor in the Department of Electronics and Electrical Engineering at Indian Institute of Technology Guwahati, has been working for more than a decade to ensure swift transition to the zero-emission transportation in India. The team have gained expertise in designing, analysis, prototyping, innovation, and research on various system and subsystems of the EV ecosystem. The works in the lab is majorly funded by industry partners, a few by government agencies, and others are self funded.

The area of expertise of the electric mobility lab although not limited to are: (i) design, prototyping and development of industrial and traction motors, (ii) Loss evaluation in motors and design optimization for its reduction (iii) Design automation for electromagnetic design, (iv) electromagnetic actuators for application in vehicles, (v) intelligent EV charging infrastructure and controllers for, (vi) causes of EV battery degradation, (vii) fast charging techniques to reduce the rate of battery degradation, (viii) power electronics converters for powertrain and charging of EVs, (ix) control strategy for traction motor, (x) optimization of the powertrain to improvise efficiency, (xi) techno-commercial analysis of EV systems, (xii) electric mobility as a service, (xiii) Applications of AI/ML in electrical machine design and parameter estimation.

The lead authors of the report, Sai Krsihna Mulpuri, Om Jee Singh, and Bikash Sah are PhD candidates working with Prof. Praveen Kumar in the Electric Mobility Lab. The other contributors are students of the MS (R) course in Electric Mobility, batch 2021-2022. The courses of MS (R) in Electric Mobility were developed in close collaborations and inputs from industry by Prof. Praveen Kumar. A few others contributors are students registered in various courses in the Department of Electronics and Electrical Engineering.

The enthusiastic team of electric mobility lab is open to collaborative projects related to various domains of electric vehicle ecosystem from organisations worldwide.

Prof. Praveen Kumar
Department of Electronics and Electrical Engineering
Indian Institute of Technology Guwahati

Sai Krishna Mulpuri
PhD Candidate, E
Mobility Lab

Om Jee Singh
PhD Candidate, E
Mobility Lab

Bikash Sah
PhD Candidate, E
Mobility Lab

Sandeep Reddy
MS (R), 2021-2022 Batch

Koushik Samanta
MS (R), 2021-2022 Batch

Praveen Nath
MS (R), 2021-2022 Batch

Sourabh Singh
MS (R), 2021-2022 Batch

Sanjay Shooray
MS (R), 2021-2022 Batch

Vijaya
PhD Candidate

Bhivesh Sharma
MS (R), 2021-2022 Batch

Harshendra N Shet
PhD Candidate

Sujeet Singh
MS (R), 2021-2022 Batch

Asif Khan
MS (R), 2021-2022 Batch

4 Executive Summary

With the government pushing for EVs, EV start-ups popping up every other day, and established players jumping on the EV bandwagon, India is on the cusp of a wide EV adaption. With the Government having put goals of wider EV adaption, also supporting the idea with subsidies and tax incentives. There is an expectation of an electric future, as we slowly see new EV products lining up in the market. But in 2021, **EVs are still much more expensive than a similar spec gasoline vehicle**, making them out of reach of most Indians. Even at their steep price, early EV adopters have had to deal with range anxiety, poor charging infrastructure, and many other issues. Also, the pandemic has not been friendly to the pockets of the populous.

To Review the accessibility of EVs in India after the pandemic, we surveyed 1700 people to gain insights into the ground reality, where our goal was to understand their perception, experience, and wants from EVs. And to find out what the future beholds for electric vehicle adoption in India.

About 90 percent of the respondents had never owned an electric vehicle. Among those who have owned an electric vehicle, two-wheelers are predominant. **A lot of the rural participants have never even heard of EVs**. Also, some people had impractical expectations from EVs for the price point they wanted the product to be at.

The right price is the most important factor people look for, with the environmental impact on 4th place when buying an EV. The younger population is the most eager to adopt EVs and is willing to pay the highest compared to older age groups. Also, in general, most of the participants were okay with paying a slight premium for EVs today. Limited options for recharging vehicles are also a very discouraging factor for EV buyers.

About 60 percent of the respondents think that EVs definitely improve the environment, and more than 65 percent think owning an EV over a gasoline-powered vehicle is an advantage.

Overall, we found that in the near term, more than 50 percent and in the long term, more than 70 percent of respondents would be looking forward to buying EVs. **With these potential buyers and possibilities of future improvements in technology, the market is ripe for the growth of the EV sector in India.**

5 Demographic Profile of Respondents

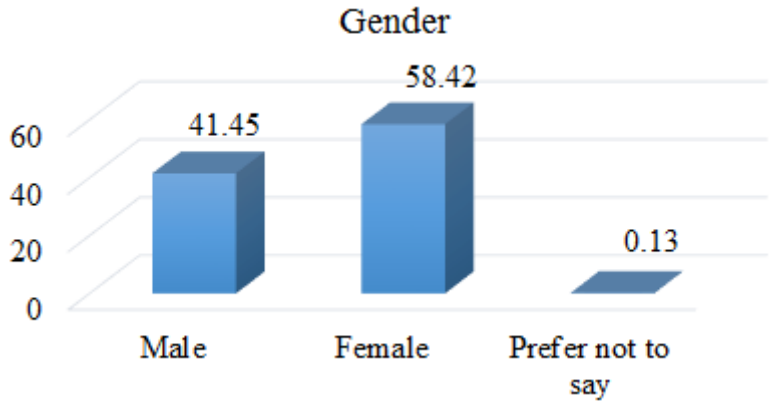
The survey aimed to determine various aspects of consumer expectations related to EVs.**The expectations vary between individuals based on gender, educational qualifications, exposure to technologies, age, and type of residents.** The survey considered possibilities to explore the expectations and opinions of various individuals incorporating the variations mentioned. The E-mobility team surveyed approximately 1700 individuals from rural and urban areas with diverse educational and professional backgrounds. The individuals were asked to answer a set of questionnaires that were communicated via online modes (e-mails, social networks, and word web posting).

The analysis on the respondent types is classified based on gender, age, highest academic level, and occupation. The plots depicting the classification of each type of respondents are given in the subsequent subsections. The plots show the consideration of diverse kinds of respondents while preparing the reports.

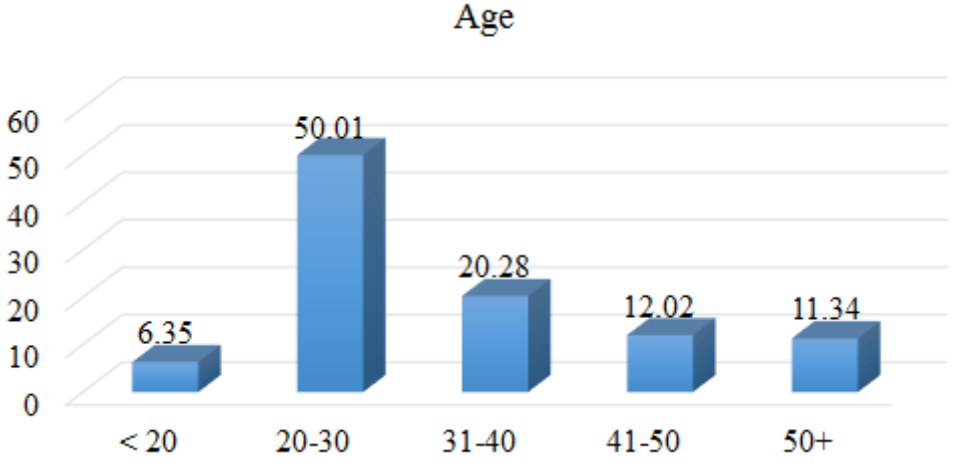
5.1 Total Responses Received

A total of 1700 respondents participated in the survey. The classification of the type of respondents are shown in percentage in the corresponding figures of subsections.

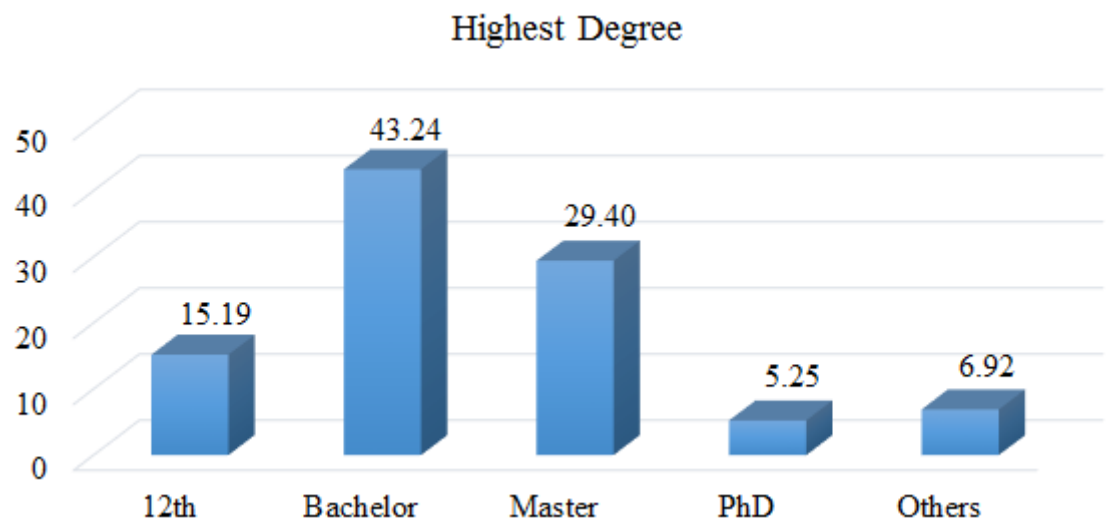
5.1.1 Gender



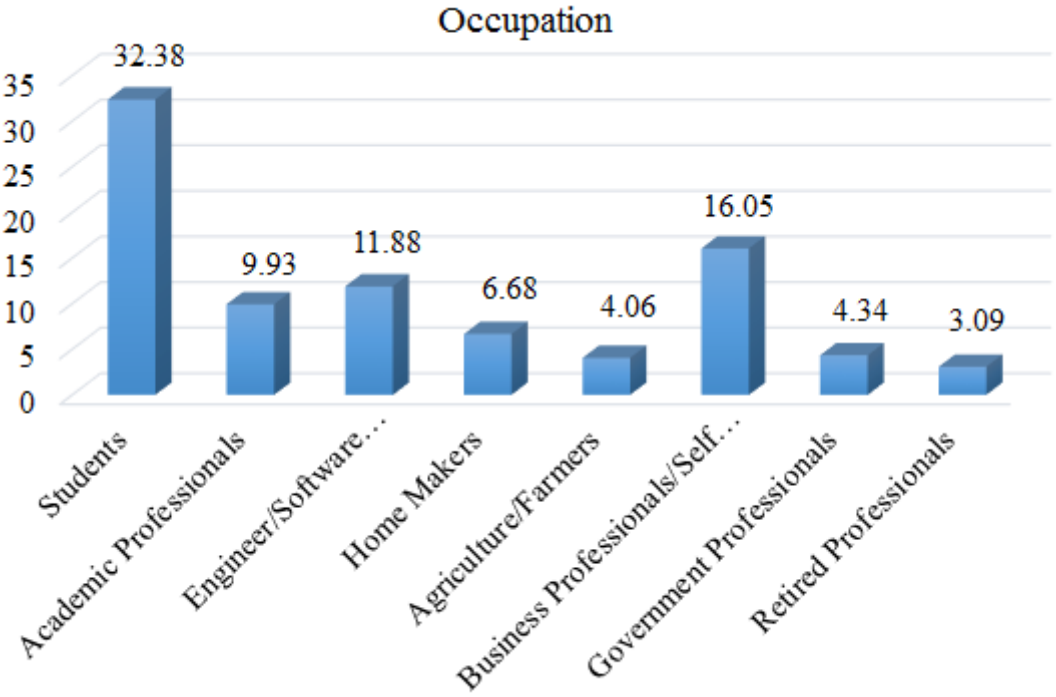
5.1.2 Age



5.1.3 Educational Qualification



5.1.4 Occupation



5.2 Insights and Analysis

Of the 1700 respondents:

1. **Gender**: 42% were male, 58% were female, and 0.13% did not prefer to mention about the gender.
2. **Age Group**: Individuals belonging to the 20-30 years age constitute 50% of the population surveyed. The other age groups that dominated were 31-40 years (20.28 %), 41-50 years (12.02 %), age above 50 years (11.34 %), and the remaining participants of age group less than 20 were around 6.35 %.
3. **Educational Qualification**: Individuals with a bachelors degree (43.24 %) dominated in terms of educational qualifications. The other respon-

dents participation percentage are 29.40 %, 5.25 %, 6.92 % and 15.19 % for masters, PhD, others and 12^{th} standards, respectively.

4. **Occupation**: The occupations of respondents varies from students to retired professionals. Since an educational institute conducted the survey, 32.38% of the respondents are students. 16.05 % are working as business professionals or are self employed or in health care sector. The engineers or software engineers or the IT professionals participated with 11.88 % responses. The remaining respondents are employed as academic professionals (9.93 %), home makers (6.68 %), agriculture sector (4.06 %), government employees (4.34 %), retired professionals (3.09 %), and others (11.58 %) which were from organised and unorganised sectors.

6 Electric Vehicle Ownership Scenario

The types of individuals owning a vehicle have a more significant impact on the penetration rate of EVs in India. **The types of ownership form the basis of risk as an individual one can take while adopting new technologies.** Further, the types of vehicles and their requirements also vary between individuals with changes in the profession. For example, an individual involved in farming would prefer to purchase low-speed, high torque with off-road capabilities rather than a sophisticated vehicle with multiple features (high speed and torque, enhanced safety features, comfort, etc.) to drive in the city or highways. Hence, an analysis is presented with a variation of EV ownership by looking into the gender and occupation of vehicle owners.

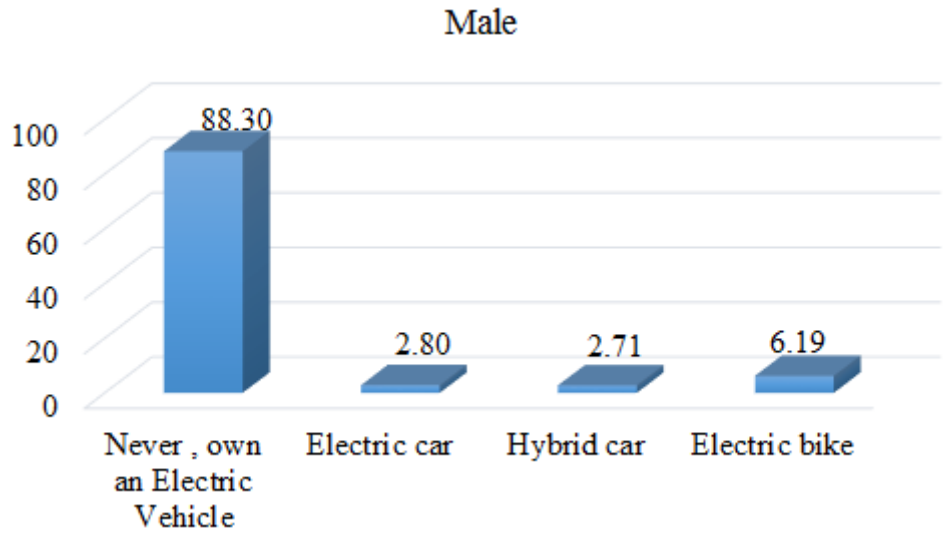
The present section illustrates the classification of EV owners based on gender and occupation. Further, it gives an idea about the type of EVs owned based on the type of employment. **Among the respondents, students constitute the highest share of EV ownership (34 %), followed by farmers (22 %).** It is observed that the majority of the respondents, regardless of occupation, do not own EV. Among the different types of EVs owned, the highest share is contributed from e-bikes, in general, except for academic professionals. Farmers, in particular, hold the highest share of e-bikes (12.5%) compared to other professionals. Similarly, the highest share of e-cars is observed among academic professionals (about 4%).

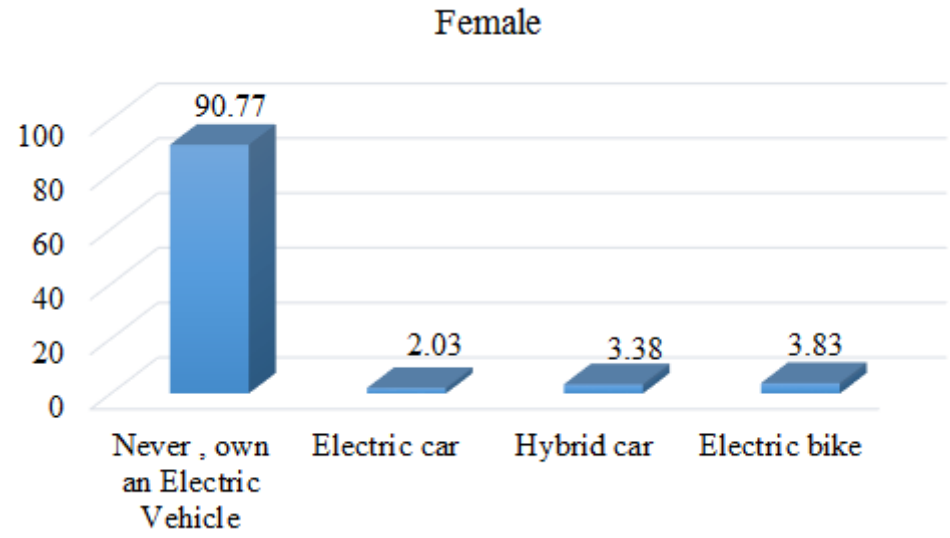
6.1 Type of Electric Vehicle Owned

The survey considered three different types of popular EVs in the Indian market viz. electric car, hybrid car, and electric bikes. **To date, Indian automotive sales is dominated by the two-wheelers or bikes.** A similar trend is expected in the case of EVs as well. Apart from the three EV types, since the automotive sales are still dominated by the ICE types vehicles, an option stating that the respondent has never owned the EV is also kept.

6.1.1 Gender

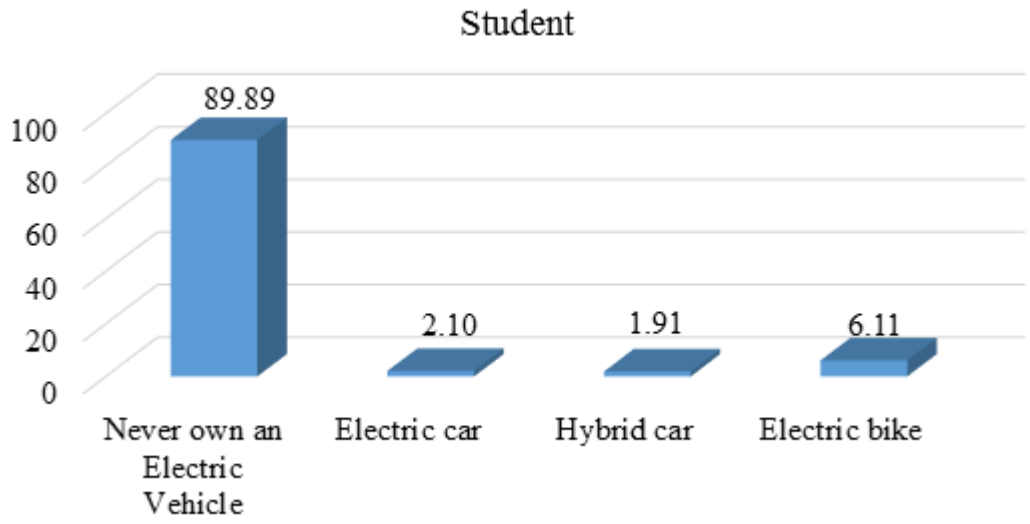
The gender impacts the types of EV an individual would prefer to purchase and ride. The amount of risk involved in different kinds of EVs is also analyzed by different gender variedly. Hence, the type of electric vehicle ownership or vehicle ownership in general changes with gender. The results obtained from the survey are shown in the figures below. Although the number of individuals owning EVs is less, the numbers give a perspective that will be discussed in the following subsections.

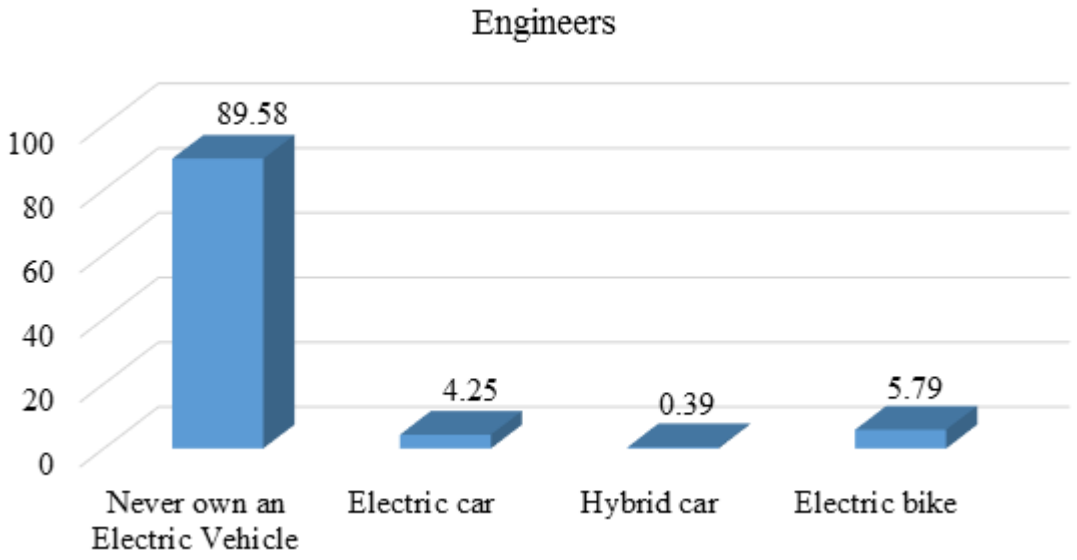


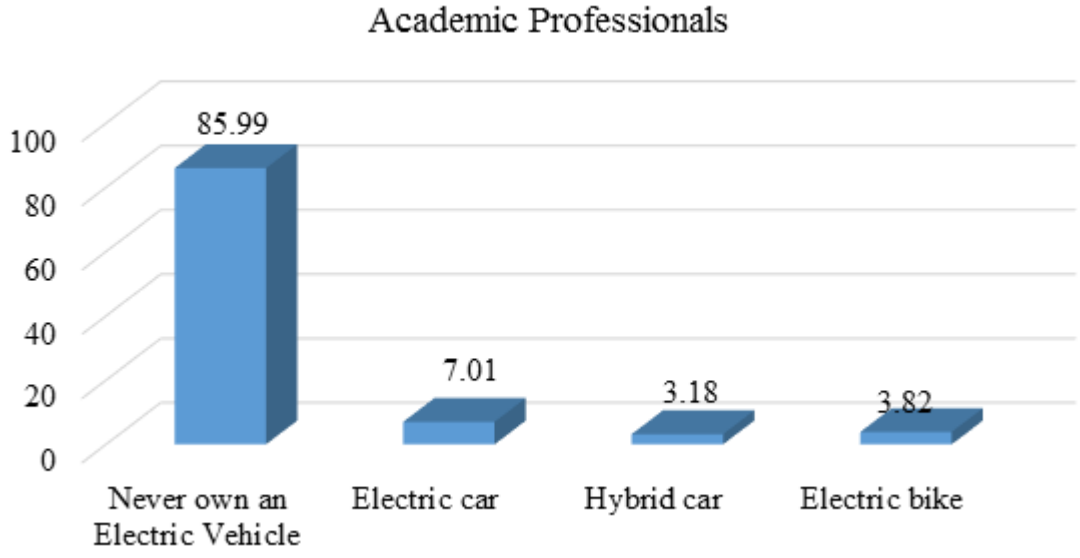


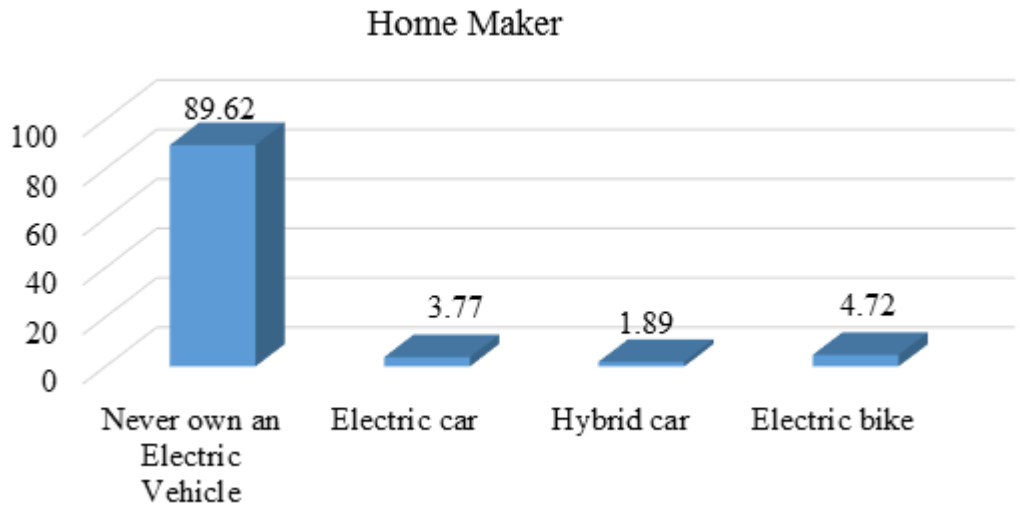
6.1.2 Occupation

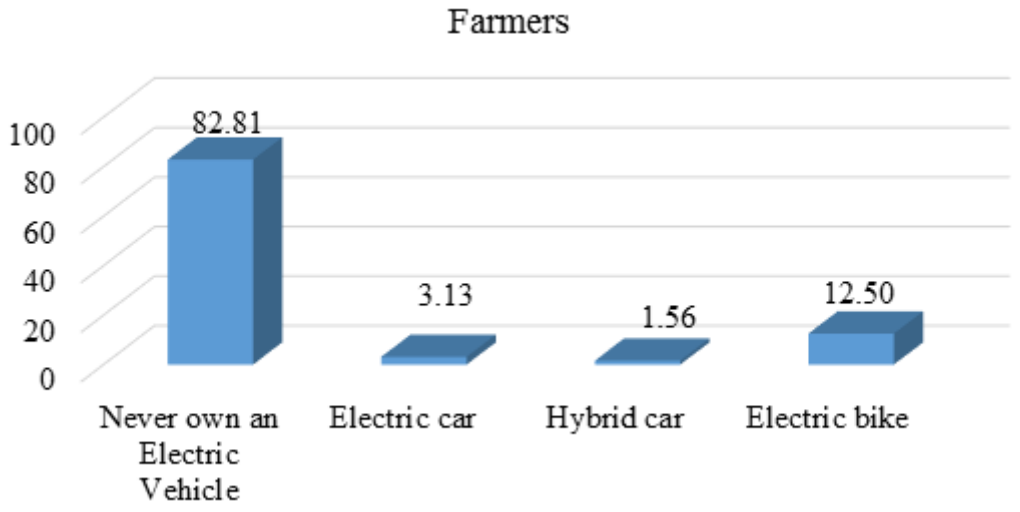
Occupation determines the amount of investment and risks an individual can undertake. Further, the education, awareness, and acceptability of newer technologies are also impacted by the occupation. For example, an individual with an occupation giving a decent salary with ample financial security would prefer to risk investing in newer technologies such as EVs rather than a person with just a decent wage.

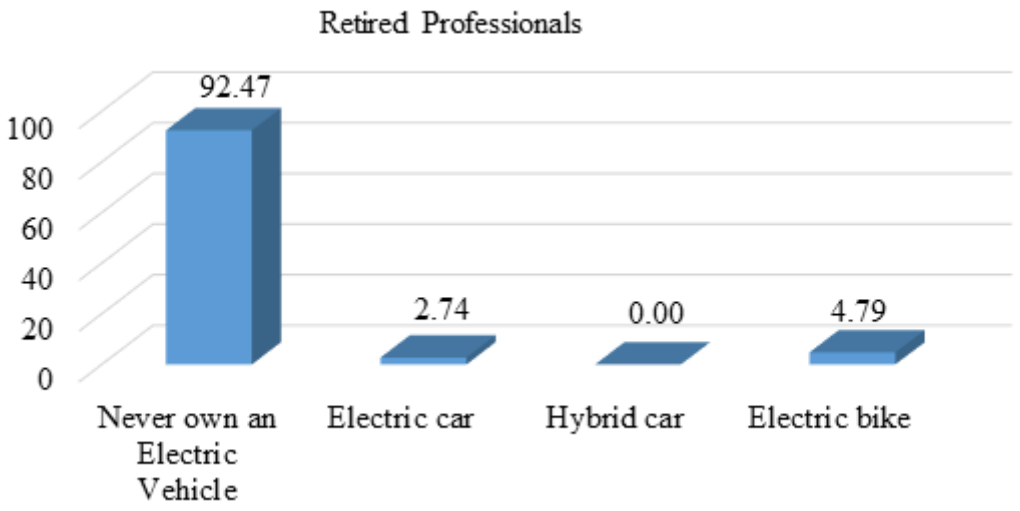

Student
89.89
2.10
1.91
6.11
100
80
60
40
20
0
Never own an Electric Vehicle
Electric car
Hybrid car
Electric bike


Engineers
89.58
4.25
0.39
5.79
100
80
60
40
20
0
Never own an Electric Vehicle
Electric car
Hybrid car
Electric bike


Academic Professionals
85.99
7.01
3.18
3.82
100
80
60
40
20
0
Never own an Electric Vehicle
Electric car
Hybrid car
Electric bike







6.2 Insights and Analysis

On the basis of the plots depicting the types of vehicle ownership by respondents of varied occupation, the following insights are drawn:

1. **Only 10% of the survey participants owned an EV, of which 54% owned two wheelers.** One of the major bottlenecks in EV is the lack of know-how in the reliable battery pack design with high energy density, besides other key technologies that involve risks.

2. The two-wheeler electric vehicles are comprised of smaller battery packs mostly rated from 3 kWh to 5 kWh. India has established battery assembly plants by various OEMs and local suppliers. Hence, two-wheelers are boosting up pace in the adoption of EVs. **Further, two-wheelers have been a preferred option for decades as it captures 80 % of the EV sales in India.**
3. **The individuals of younger generations (age between 20 to 40 years) find two-wheelers as an attractive option.** Further, since the finances involved in the two-wheelers are more petite, many individuals consider taking risks. The survey also has respondents dominated by individuals of younger generations (43.87 %).
4. **The EV technologies are not popular among residents in rural areas.** Moreover, the rural populations of India prefer to go with established technologies those are proved to be robust and reliable. However, attempts were made by the electric-mobility lab to disseminate knowledge about EVs. **The conclusive data collected after awareness shows that majority preferred to buy two-wheelers only.**

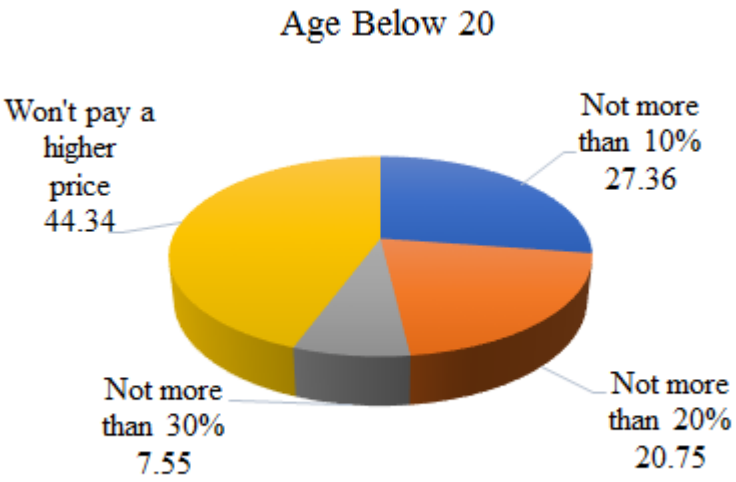
7 Price Band Expectations for Electric Vehicle Deployment

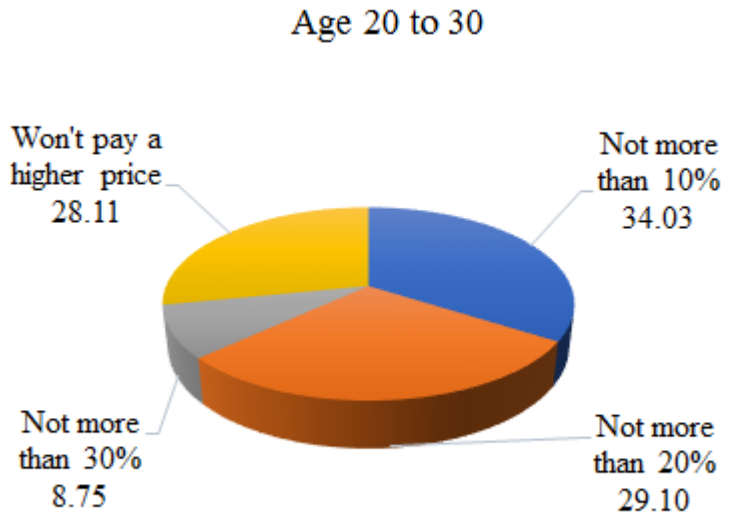
The price of a newer technology introduced in the market has a more significant role in ensuring mass trials and acceptance. **An established technology is believed to be reliable, and the mass considers investing to use it appropriately. EV being a new technology, is known to have safety concerns because of the presence of the battery.** Further, the infrastructure to switch from ICE-based vehicles to EVs is also developed in India. Hence, an individual who wishes to invest in EVs will consider a lower price when compared to ICE-based vehicles as the only cash-in factor.

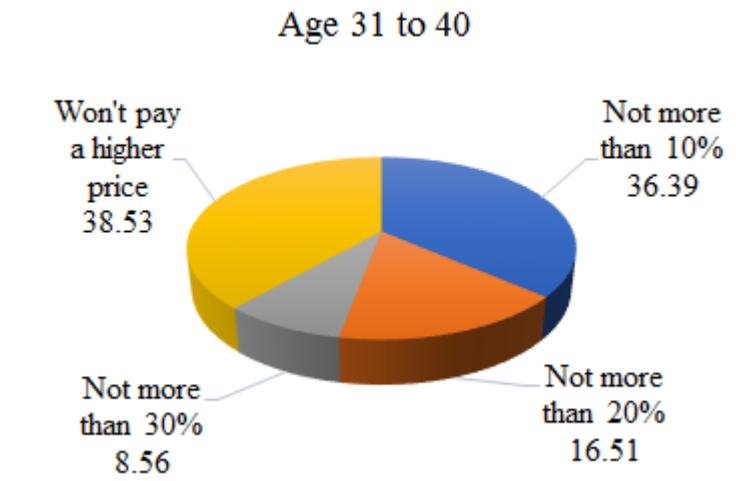
This section presents insights into the individual's expectations of EV's price compared to ICE vehicles. The insights are gained based on the classification of age, educational qualifications, and occupation is used to develop a suitable pricing strategy for target acceptance of EVs among prospective automobile customers. The analysis of the age-wise classification of the responses suggests that **many individuals apart from those in younger generations (20-30 years age group) are not willing to pay a higher price for EVs.** Among different professionals, farmers and housemakers, followed by business/self-employed/healthcare professionals, are reluctant to buy EVs priced higher than ICE vehicles. However, in general, **a significant percentage of respondents are willing to buy EVs priced up to 20% higher than ICE vehicles.**

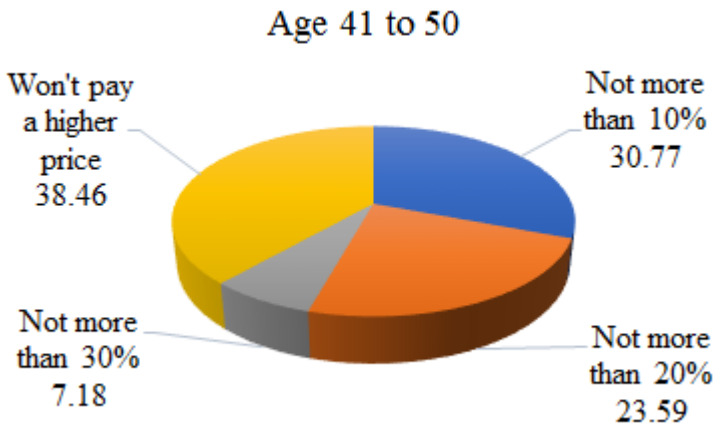
7.1 How much more are you willing to pay for an Electric Vehicle with more or less the same functionality as an ICE Vehicle?

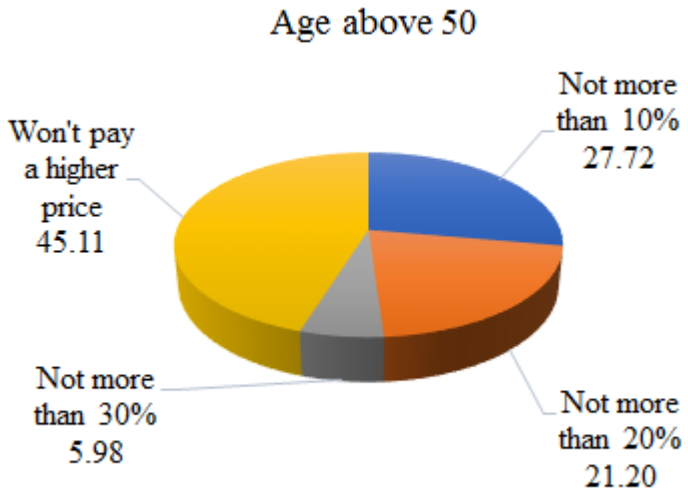
7.1.1 Age



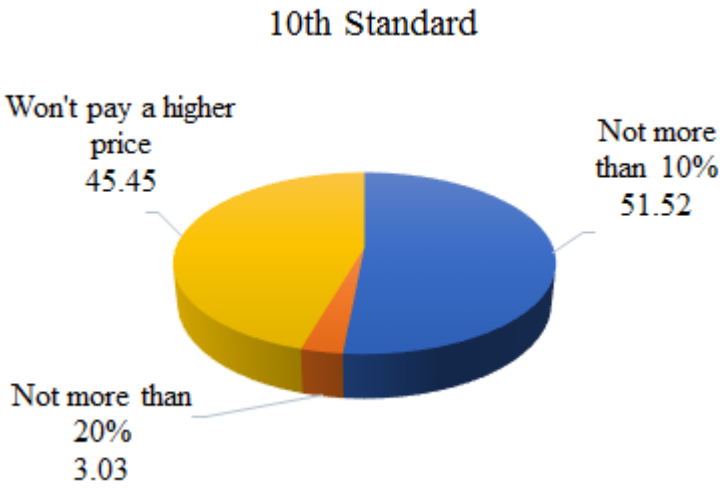


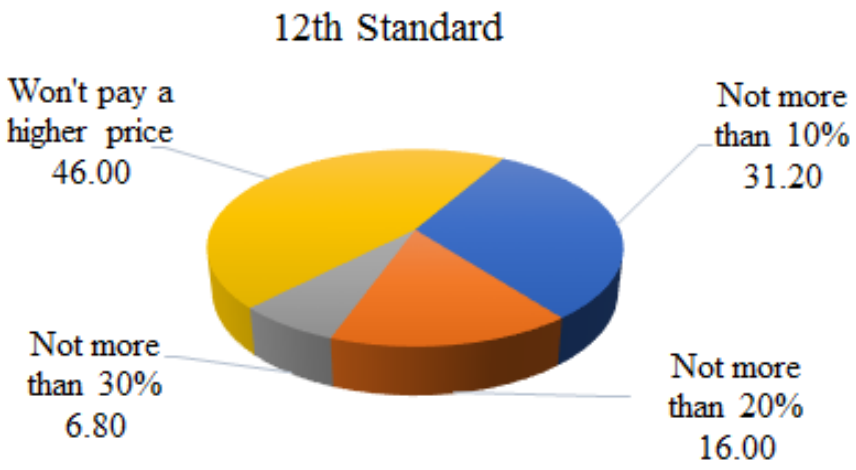


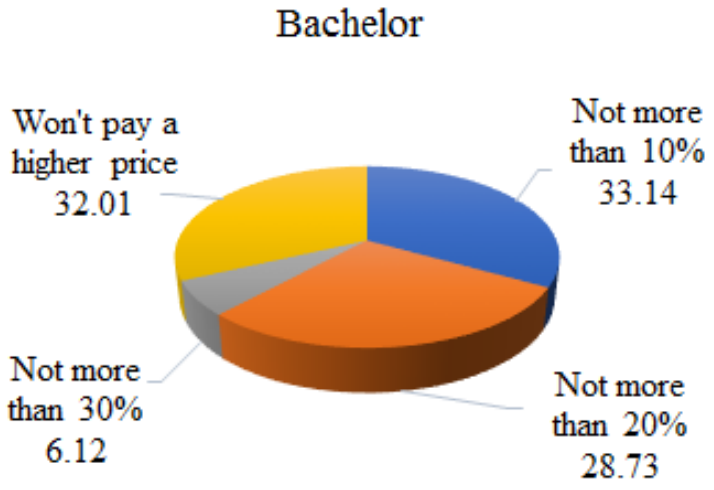


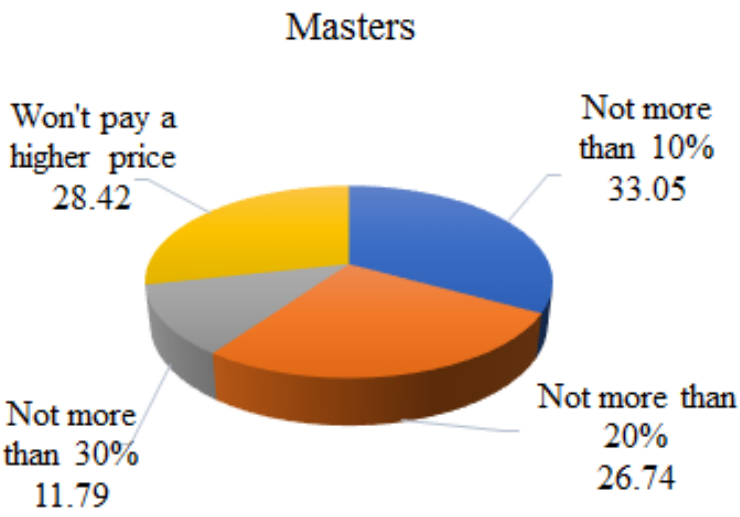


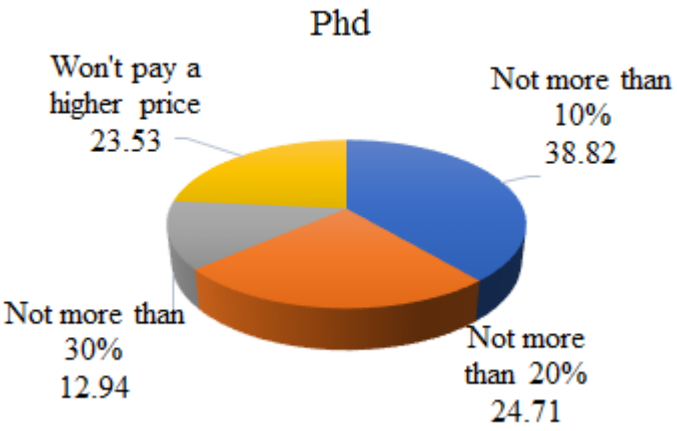
7.1.2 Education Qualification



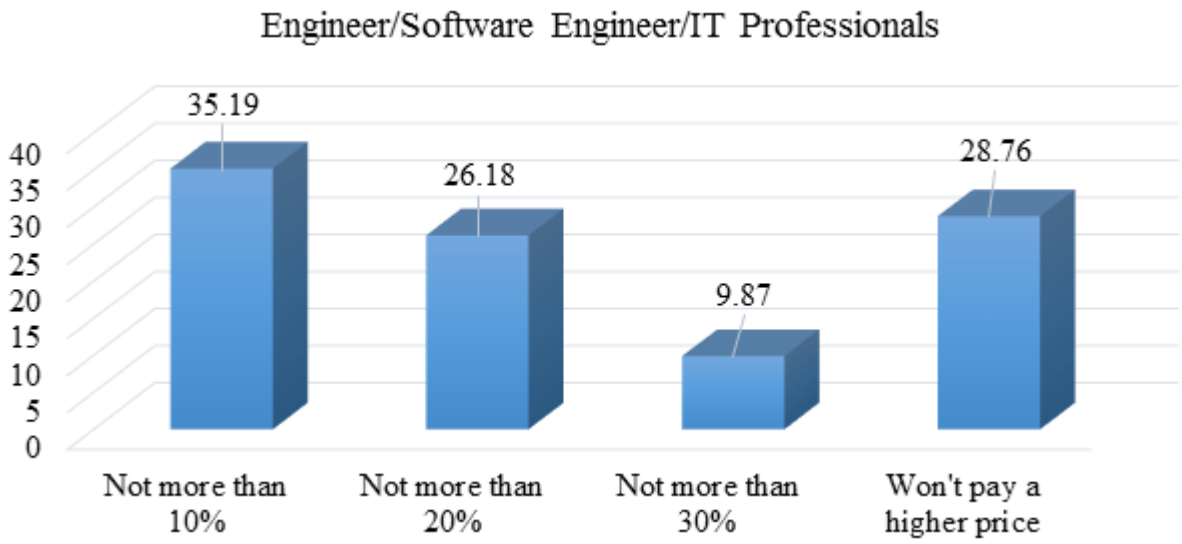

12th Standard
Won't pay a higher price 46.00
Not more than 10% 31.20
Not more than 30% 6.80
Not more than 20% 16.00

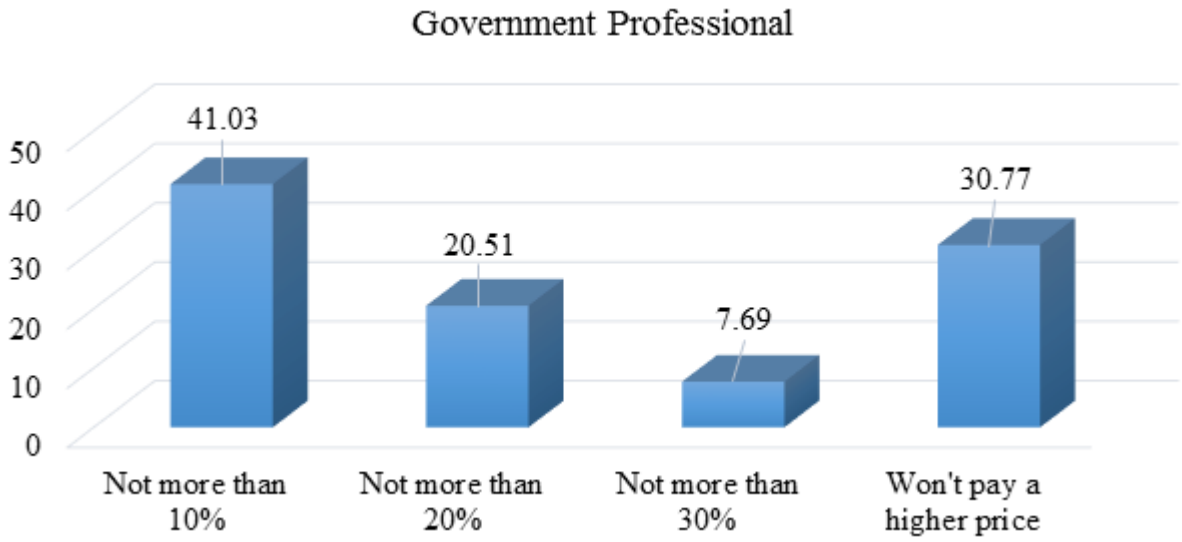

Bachelor
Won't pay a higher price 32.01
Not more than 10% 33.14
Not more than 30% 6.12
Not more than 20% 28.73


Masters
Won't pay a higher price 28.42
Not more than 10% 33.05
Not more than 30% 11.79
Not more than 20% 26.74

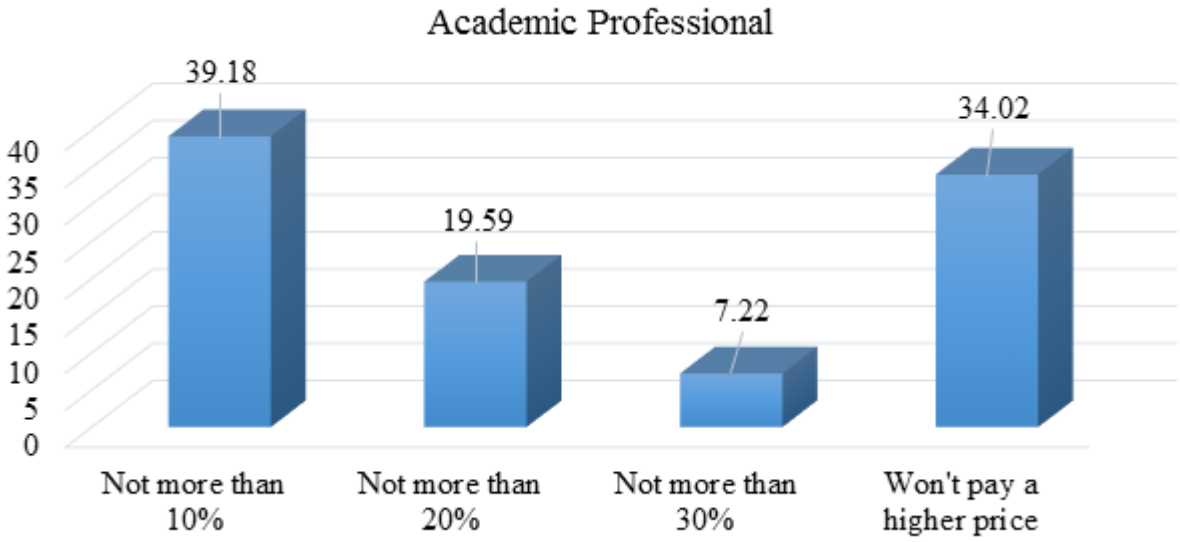


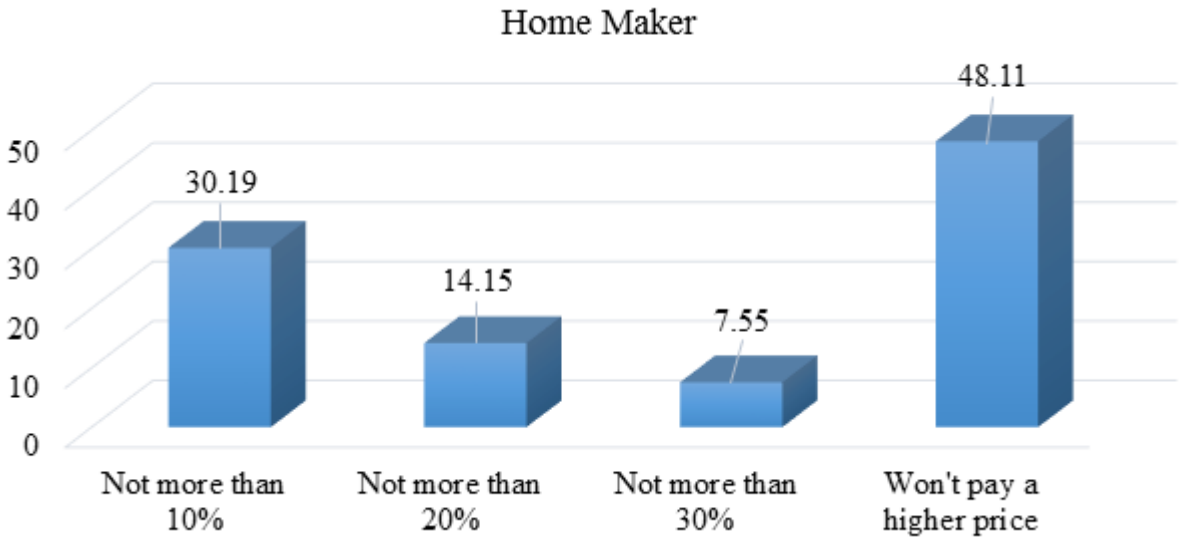
7.1.3 Occupation

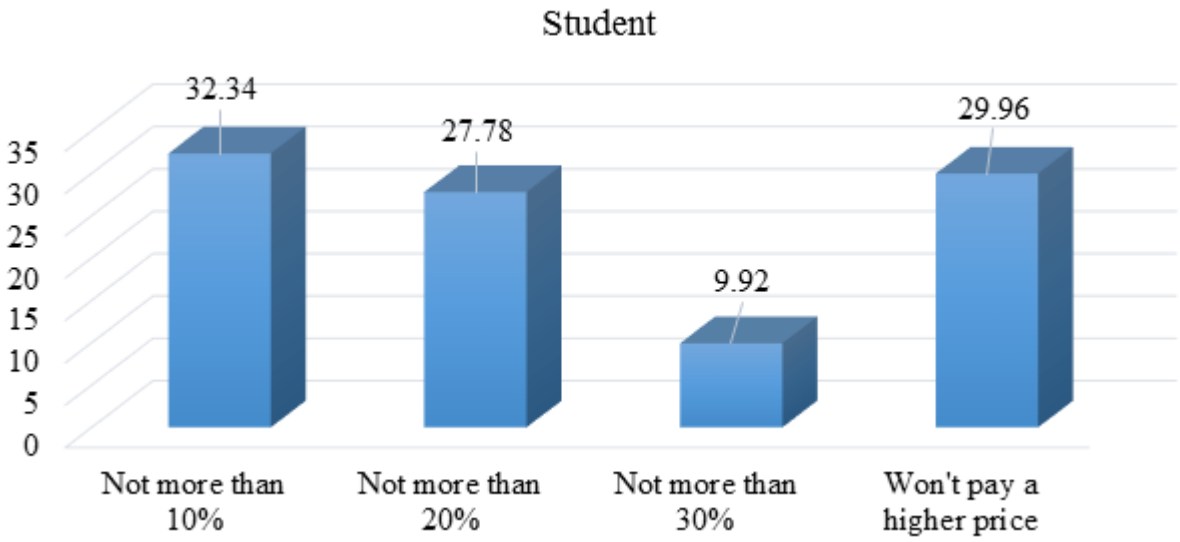


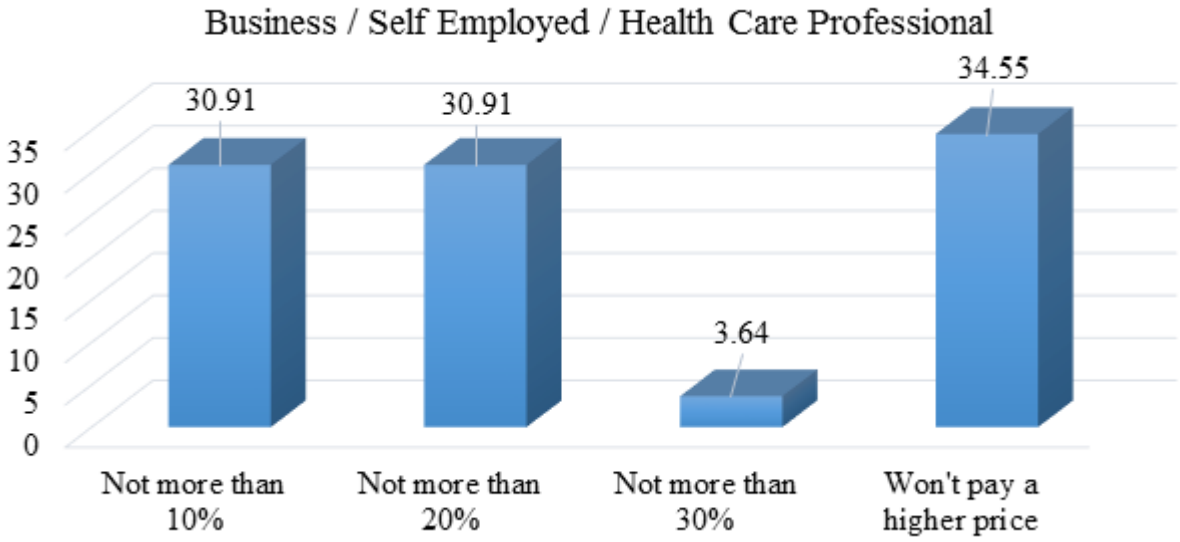


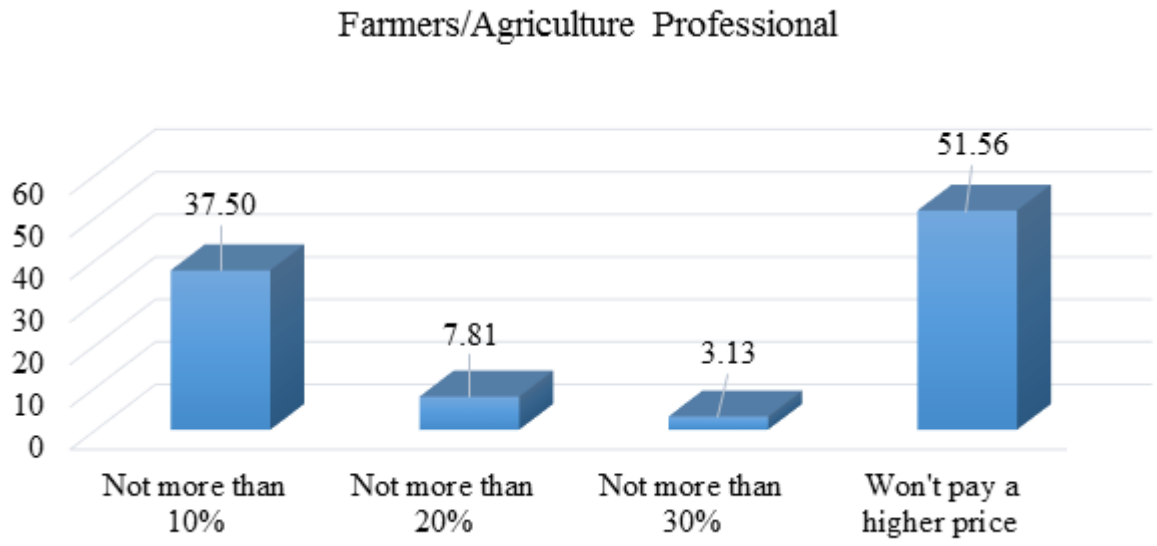

Retired Professional
37.21
25.58
6.98
30.23
40
35
30
25
20
15
10
5
0
Not more than 10%
Not more than 20%
Not more than 30%
Won't pay a higher price


Academic Professional
39.18
19.59
7.22
34.02
40
35
30
25
20
15
10
5
0
Not more than 10%
Not more than 20%
Not more than 30%
Won't pay a higher price


Home Maker
30.19
14.15
7.55
48.11
50
40
30
20
10
0
Not more than 10%
Not more than 20%
Not more than 30%
Won't pay a higher price


Student
32.34
27.78
9.92
29.96
35
30
25
20
15
10
5
0
Not more than 10%
Not more than 20%
Not more than 30%
Won't pay a higher price


Business / Self Employed / Health Care Professional
30.91
30.91
3.64
34.55
35
30
25
20
15
10
5
0
Not more than 10%
Not more than 20%
Not more than 30%
Won't pay a higher price


Farmers/Agriculture Professional
37.50
7.81
3.13
51.56
60
50
40
30
20
10
0
Not more than 10%
Not more than 20%
Not more than 30%
Won't pay a higher price

7.2 Insights and Analysis

The price band and expectations of the customers are in general challenging to the manufacturers. **OEMs do not always meet customers' expectations on the functionalities and reliability, but a trade-off between investment and required functionalities and reliability is always seen.** Based on the data collected, the following insights are built:

1. The majority of the participants in all age groups, educational qualifications, and occupation are **willing to pay up to 10% more for EVs vis-a-vis gasoline-powered vehicle' cost.**
2. People with high school education tend not to pay a higher amount than the gasoline-powered vehicle' cost. People with education up to a bachelor's degree tend to pay slightly higher than the gasoline-powered vehicle's cost. The majority of the participants with masters and Ph.D. are inclined in buying the electric vehicle even at a higher price than a gasoline-powered vehicle. In general,the education qualification raises concerns about the climatic changes and the requirements of transition from carbon-emitting fossil fuel-based systems to greener alternatives. **Hence, respondents with higher qualifications are seen to be willing to invest higher in EVs.**
3. **Individuals working with government organizations** are **unwilling to pay for EVs** if it costs more than the ICE-based vehicle.
4. Most **academics and retired professionals** are **willing to pay a slightly higher amount** than the ICE-based vehicle.
5. Individuals who mentioned occupation as homemakers are **unwilling to pay higher than the ICE-based vehicle.** In general, homemakers do not prefer to take the risk of newer technologies.
6. **Most people from business/self-employed and healthcare sectors are willing to pay a slightly higher amount.** In contrast, most people from farming/agriculture backgrounds are not willing to pay a higher amount for EVs.

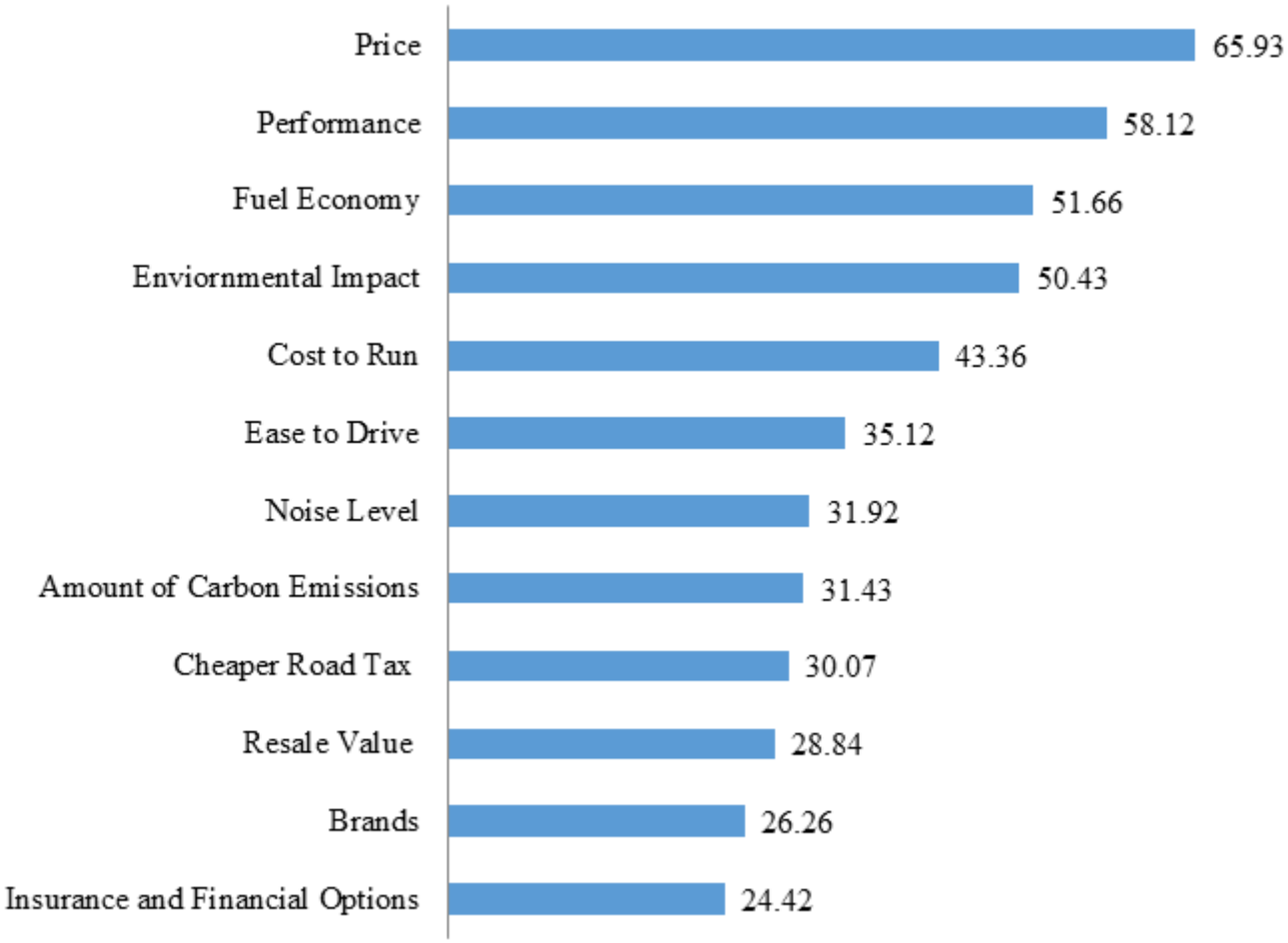
8 Factors Contemplating Electric Vehicle Procurement

The EVs have various benefits when compared to ICE-based vehicles. These benefits are always weighed against a **set of general check-points that an individual considers while buying an ICE-based vehicle.** This section looks into the critical factors an individual might consider while purchasing EVs. These include- **price, performance, fuel economy, environmental impact, maintenance or running cost, ease to drive, noise level, carbon emissions, road tax, resale value, brand, insurance, and financing options**. The re-

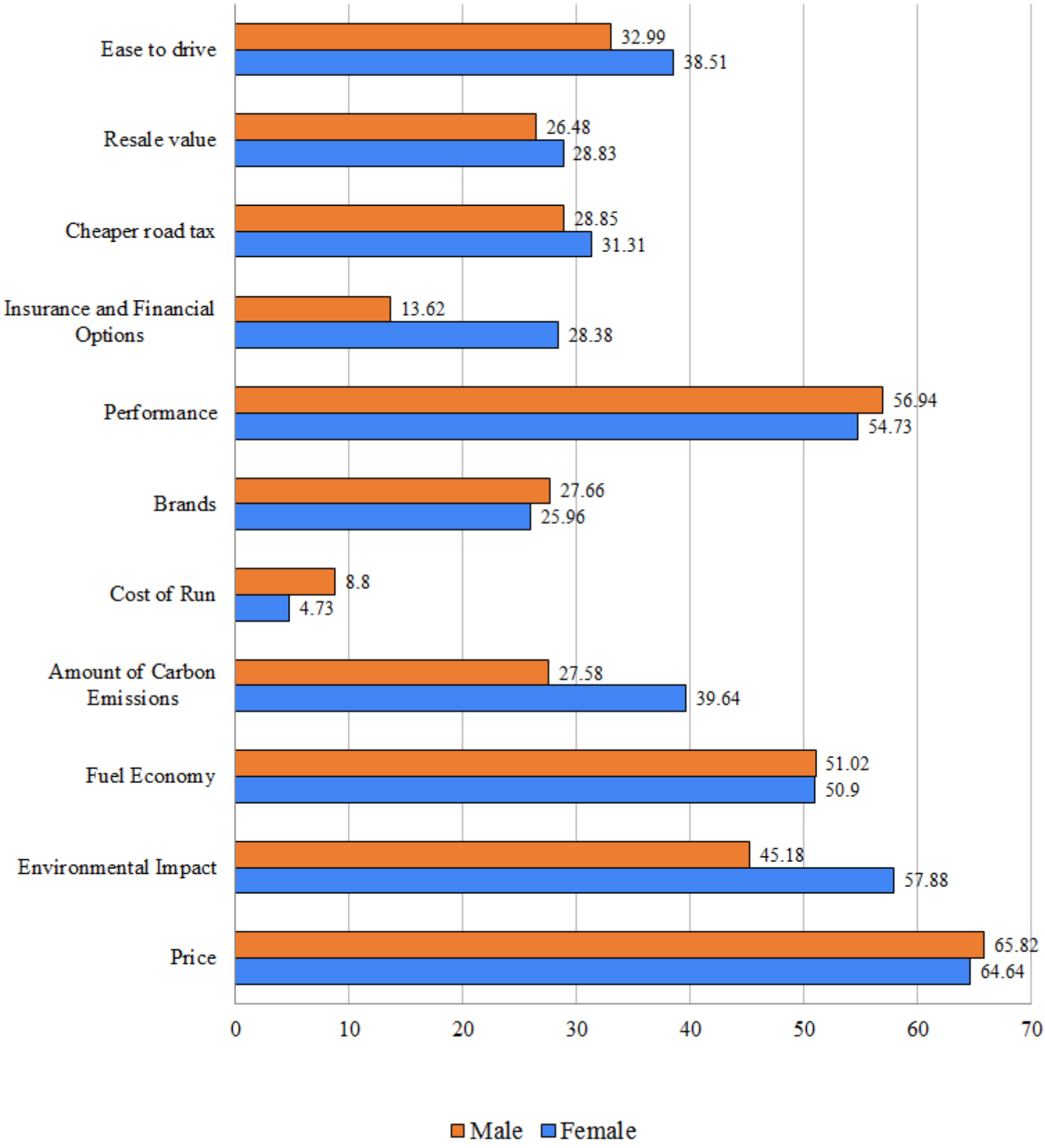
spondents were provided with a set of choices to select multiple options for this question.

8.1 What factors do you consider when buying an electric vehicle?

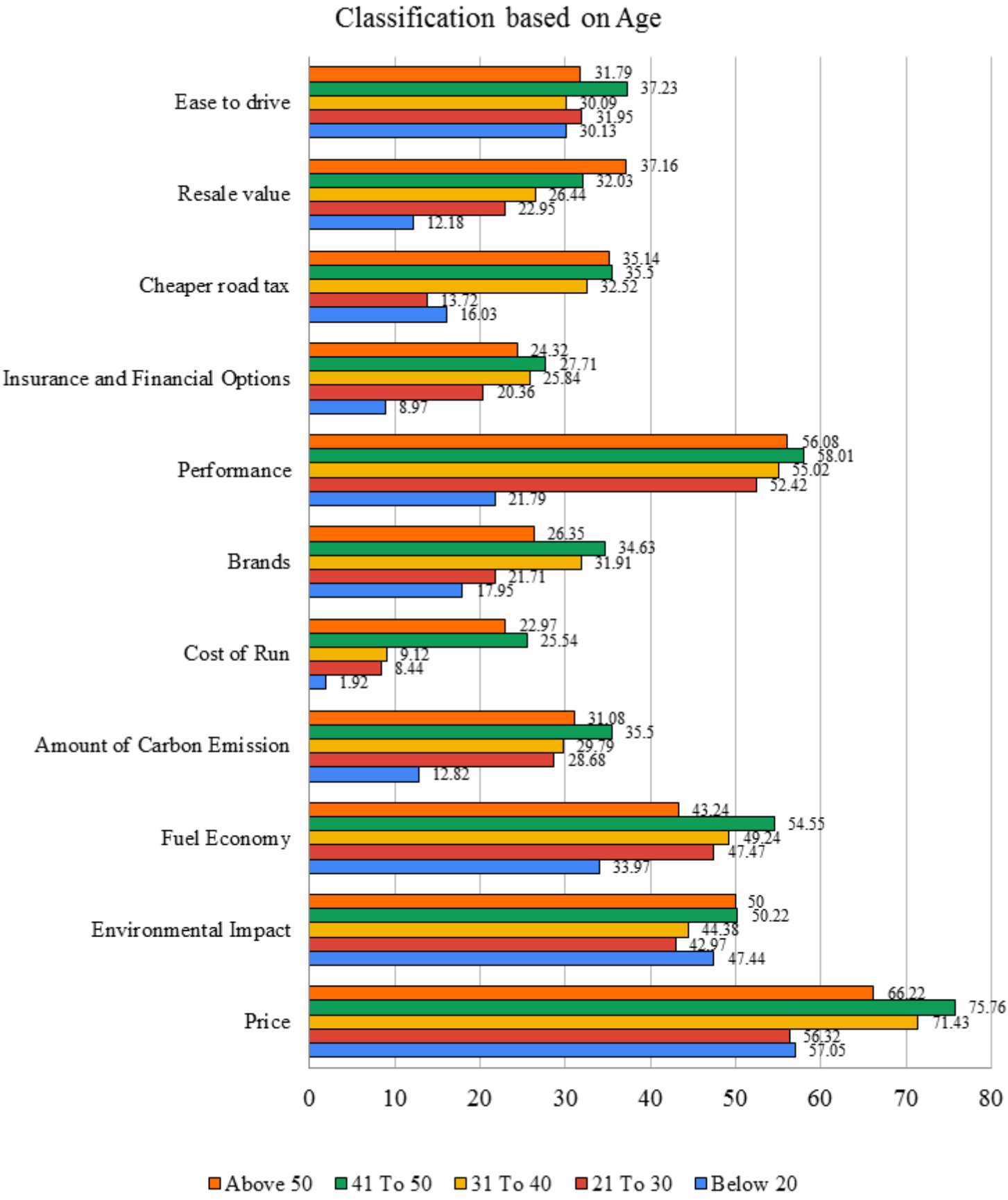
This question is floated to the respondents to find out the factors which are majorly considered by an individual while purchasing EVs. **Price emerged as a major deciding factor by any individual while purchasing EVs.** The other factors are also shown in the plot. These factors are categorically studied for different genders, age groups, educational qualifications, and occupations.



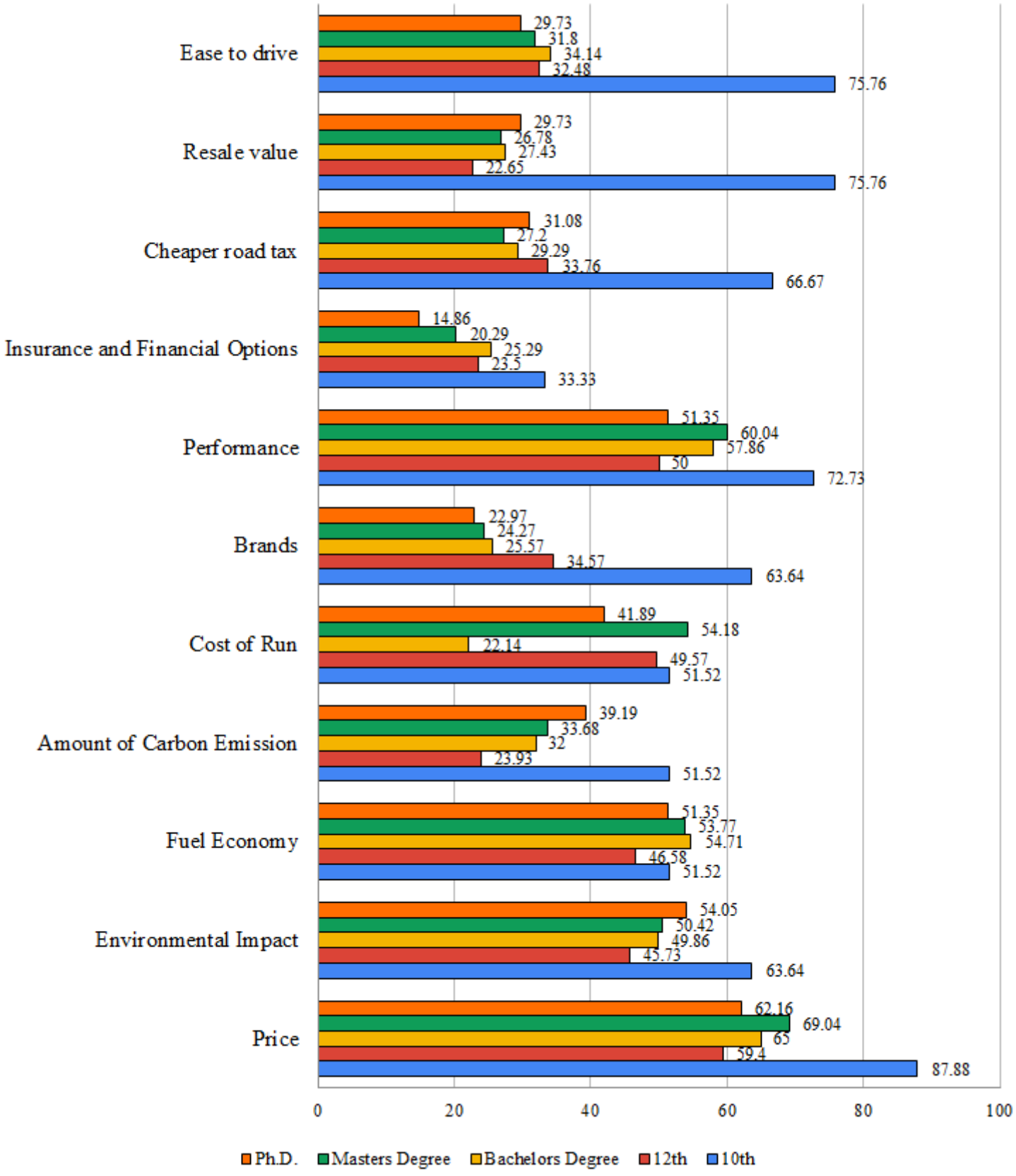
8.1.1 Gender


Ease to drive
32.99
38.51
Resale value
26.48
28.83
Cheaper road tax
28.85
31.31
Insurance and Financial Options
13.62
28.38
Performance
56.94
54.73
Brands
27.66
25.96
Cost of Run
8.8
4.73
Amount of Carbon Emissions
27.58
39.64
Fuel Economy
51.02
50.9
Environmental Impact
45.18
57.88
Price
65.82
64.64
0
10
20
30
40
50
60
70
Male
Female

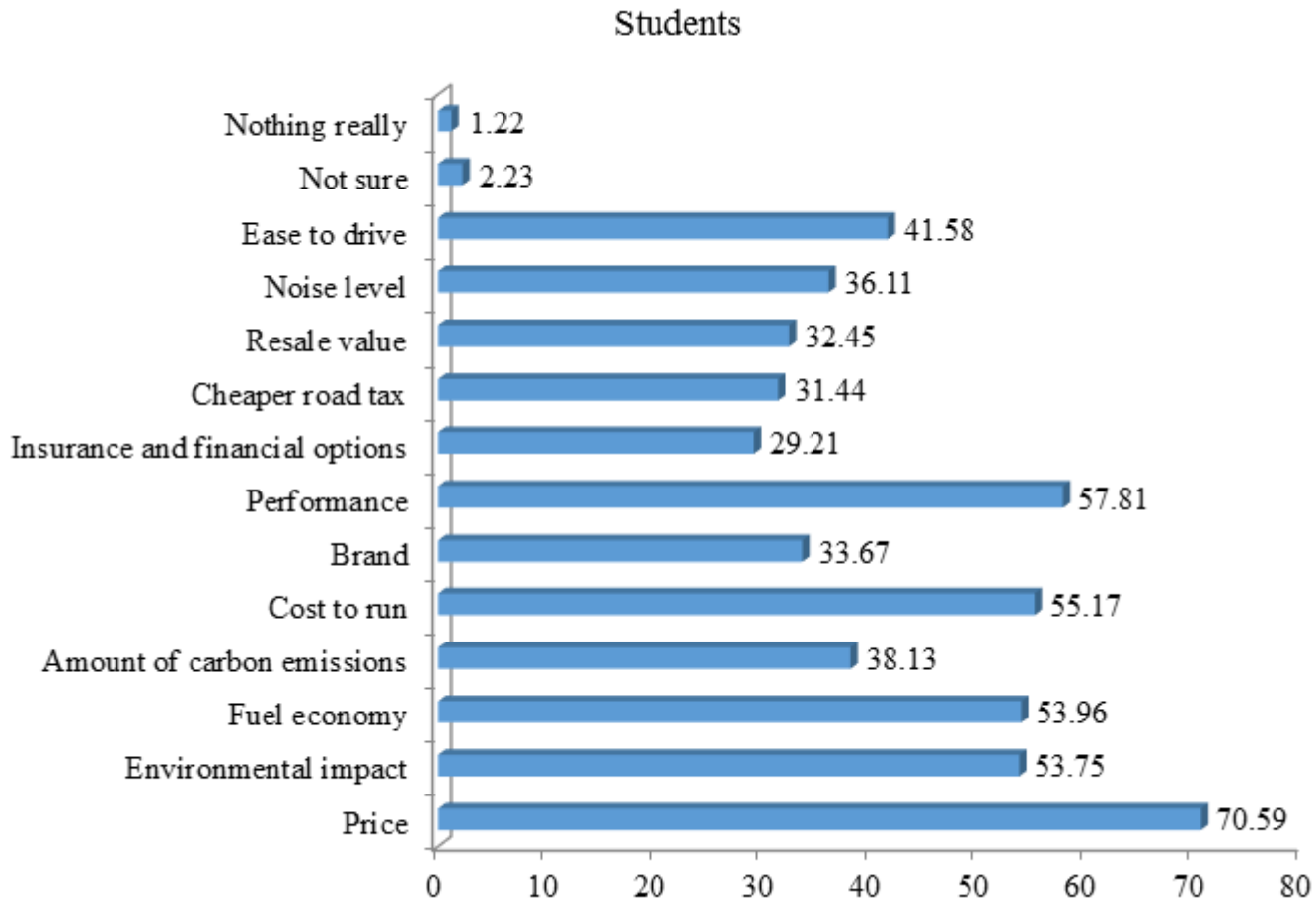
8.1.2 Age

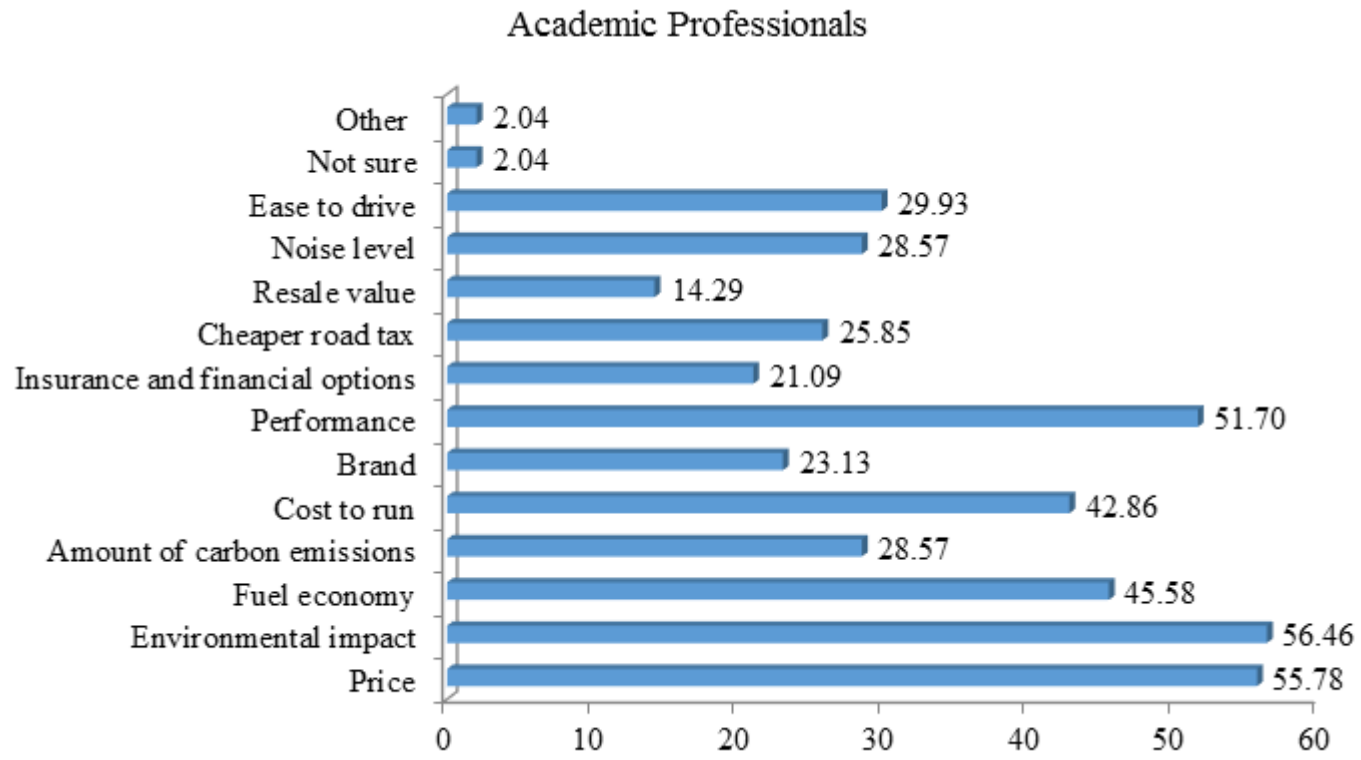

Classification based on Age
Ease to drive
31.79
37.23
30.09
31.95
30.13
Resale value
37.16
32.03
26.44
22.95
12.18
Cheaper road tax
35.14
35.5
32.52
13.72
16.03
Insurance and Financial Options
24.32
27.71
25.84
20.36
8.97
Performance
56.08
58.01
55.02
52.42
21.79
Brands
26.35
34.63
31.91
21.71
17.95
Cost of Run
22.97
25.54
9.12
8.44
1.92
Amount of Carbon Emission
31.08
35.5
29.79
28.68
12.82
Fuel Economy
43.24
54.55
49.24
47.47
33.97
Environmental Impact
50
50.22
44.38
42.97
47.44
Price
66.22
75.76
71.43
56.32
57.05
0
10
20
30
40
50
60
70
80
Above 50
41 To 50
31 To 40
21 To 30
Below 20

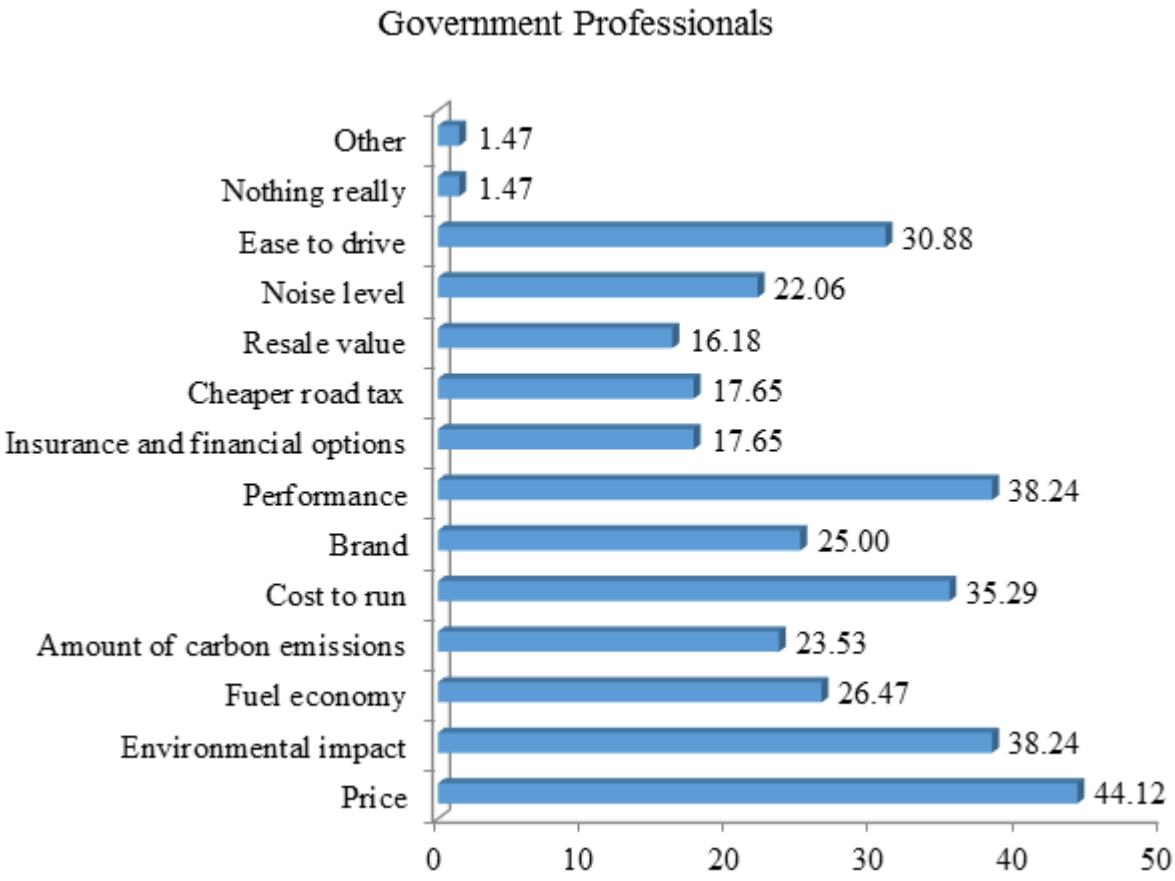
8.1.3 Education Qualification

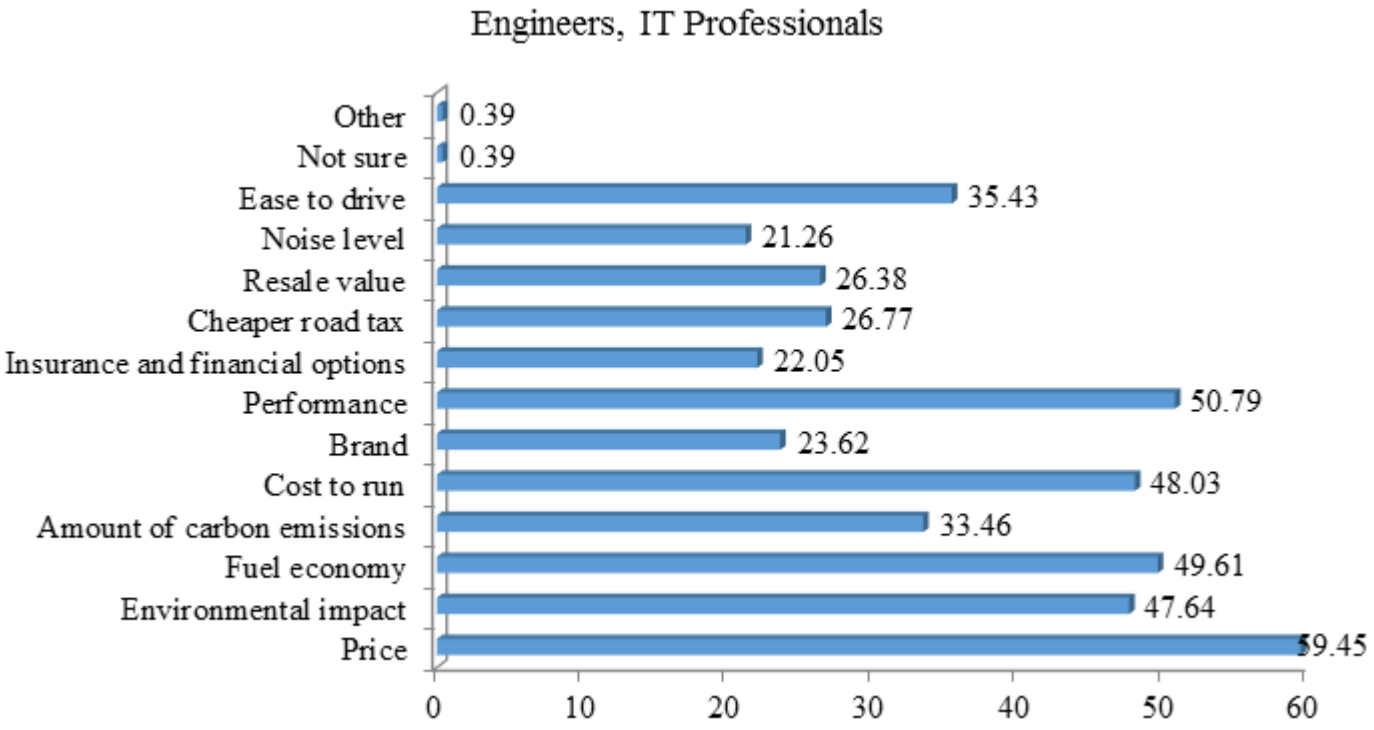


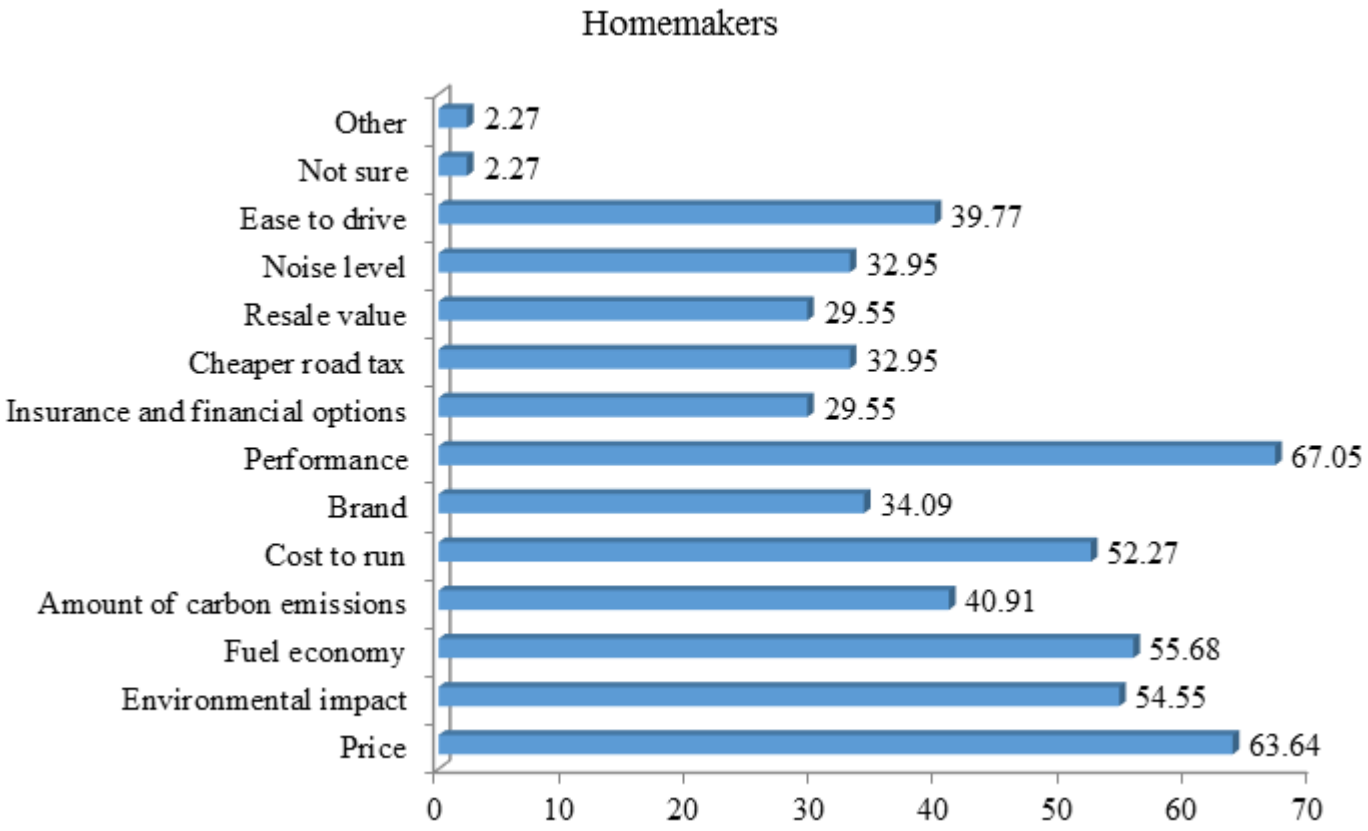
8.1.4 Occupation





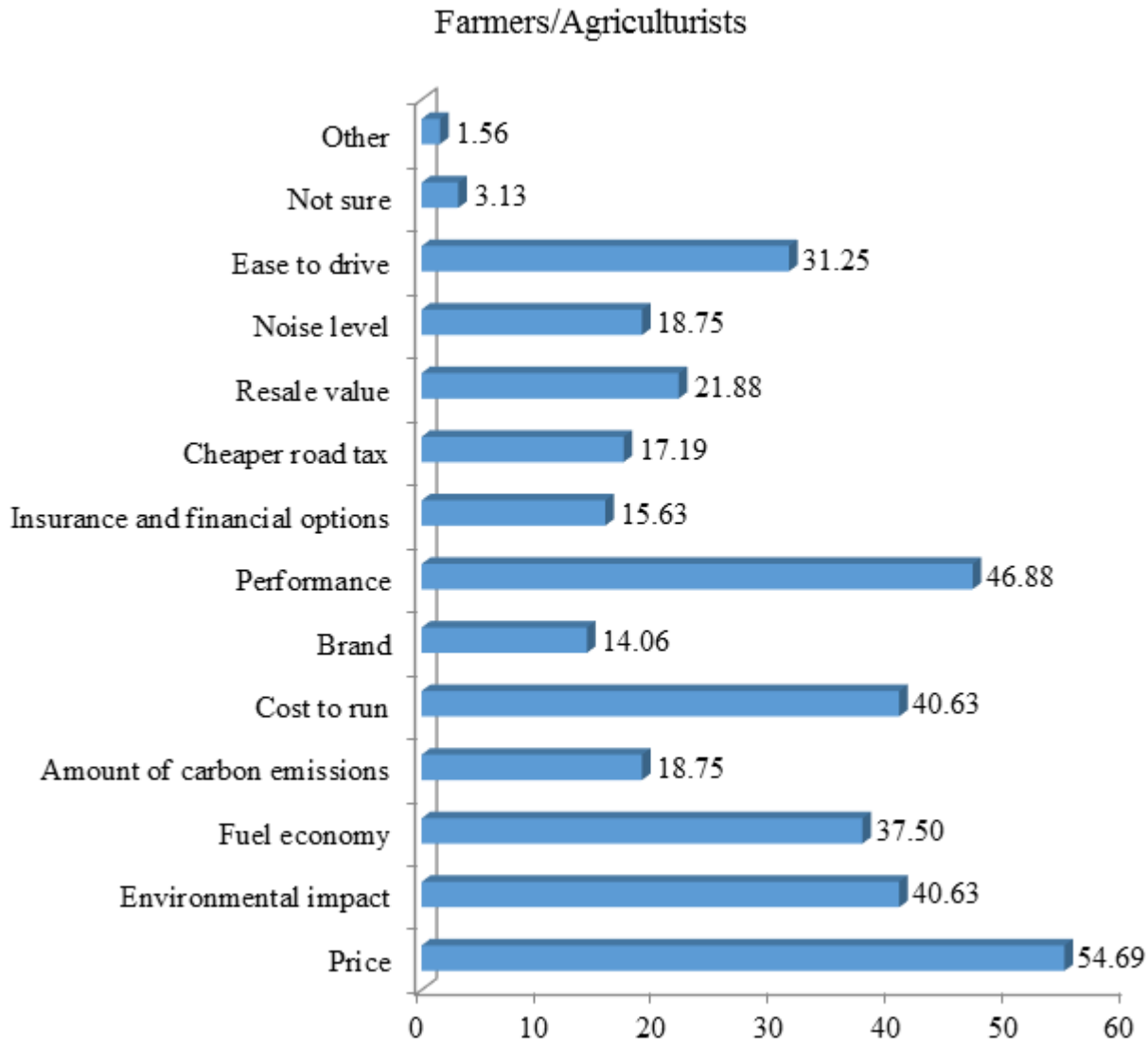

Government Professionals
Other
Nothing really
Ease to drive
Noise level
Resale value
Cheaper road tax
Insurance and financial options
Performance
Brand
Cost to run
Amount of carbon emissions
Fuel economy
Environmental impact
Price
1.47
1.47
30.88
22.06
16.18
17.65
17.65
38.24
25.00
35.29
23.53
26.47
38.24
44.12
0
10
20
30
40
50


Engineers, IT Professionals
Other
Not sure
Ease to drive
Noise level
Resale value
Cheaper road tax
Insurance and financial options
Performance
Brand
Cost to run
Amount of carbon emissions
Fuel economy
Environmental impact
Price
0.39
0.39
35.43
21.26
26.38
26.77
22.05
50.79
23.62
48.03
33.46
49.61
47.64
59.45
0
10
20
30
40
50
60


Homemakers
Other
Not sure
Ease to drive
Noise level
Resale value
Cheaper road tax
Insurance and financial options
Performance
Brand
Cost to run
Amount of carbon emissions
Fuel economy
Environmental impact
Price
2.27
2.27
39.77
32.95
29.55
32.95
29.55
67.05
34.09
52.27
40.91
55.68
54.55
63.64
0
10
20
30
40
50
60
70


Business, self-employed and healthcare professionals
Not sure
Ease to drive
Noise level
Resale value
Cheaper road tax
Insurance and financial options
Performance
Brand
Cost to run
Amount of carbon emissions
Fuel economy
Environmental impact
Price
5.62
26.97
22.47
14.61
39.33
17.98
52.81
25.84
30.34
17.98
42.70
37.08
41.57
0
10
20
30
40
50
60


Retired Professionals
Not sure
Ease to drive
Noise level
Resale value
Cheaper road tax
Insurance and financial options
Performance
Brand
Cost to run
Amount of carbon emissions
Fuel economy
Environmental impact
Price
2.27
47.73
43.18
27.27
38.64
29.55
75.00
34.09
63.64
36.36
79.55
68.18
86.36
0
10
20
30
40
50
60
70
80
90


Farmers/Agriculturists
Other
Not sure
Ease to drive
Noise level
Resale value
Cheaper road tax
Insurance and financial options
Performance
Brand
Cost to run
Amount of carbon emissions
Fuel economy
Environmental impact
Price
1.56
3.13
31.25
18.75
21.88
17.19
15.63
46.88
14.06
40.63
18.75
37.50
40.63
54.69
0
10
20
30
40
50
60

8.2 Insight and Analysis

1. **Price, performance, and environmental impacts are the key buying factors considered while buying an EV.** Factors like **insurance, financing options, brands, resale value, and road tax are not the major thought factors** considered while buying an EV. The price and performance are analyzed while purchasing ICE-based vehicles as well. However, environmental concerns are not taken into consideration. A few reasons for environmental impacts being one of the significant factors while buying EVs are:
    - The EVs worldwide are boosted with the basis to improve environmental conditions and air quality. **Hence, an individual aware of the benefits of EVs will always consider environmental conditions as a major factor for shifting towards a newer technology such as EV.**
    - Majority of the respondents in the survey were elite individuals who were primarily aware of the changes in the environments via a variety of social media platforms and news sources worldwide. This insight is further supported by the finding as well, which is revealed in the previous subsection. **The individuals with higher qualifications prefer to buy EVs when compared to individuals with a bachelor's degree.**
2. The evolution in the industry with the emergence of a variety of start-ups focused on EVs has diluted the brand value in the EV ecosystem. **Individuals often prefer to buy products considering the functionalities, safety, and reliability irrespective of a bigger brand name.** Further, the plots showed that an individual would purchase EVs of a particular competitive brand against established and have a suitable price range with appropriate support services.
3. **Insurance, financial options, and road tax are secondary factors considered while buying an EV.** Resale value is not considered a significant factor while buying. A reason behind the output might be the financial status of the respondents of the surveys. The respondents are either employed, hence have financial security or students who expect to be secured in the near future.
4. When **gender** is looked into, **both price and performance are again the significant factors** considered by both male and female categories.
5. On the basis of **age, except for the age group below 20**, the rest of the age groups have considered **price and performance as their major factors while buying EVs.**
6. Occupation of individuals is essential while looking into the dominating factors impacting the purchase of EVs. Hence, they are differentially discussed here. Following were the most critical factors for people from dif-

ferent professional backgrounds. The percentage value mentioned in the brackets represents the choice of individuals from various professional backgrounds expressed as a percentage of total individuals belonging to the same background.

- **Students**:
  Price (70.59%), performance (57.81%), cost to run (55.17%), fuel economy (53.96%), environmental impact (53.75%).
- **Farmers/agriculturists**:
  Price (54.69%), performance (46.68%), cost to run and environmental impact (40.63%).
- **Retired professionals**:
  Price (86.36%), fuel economy (79.55%), performance (75%), environmental impact (68.18%), cost to run (63.44%).
- **Homemakers**:
  Performance (67.05%), price (63.64%).
- **Engineers and IT professionals**:
  Price (59.45%), performance (50.79%), fuel economy (49.61%), cost to run (48.03%)
- **Government professionals**:
  Price (44.12%), environmental impact (38.24%), performance (38.24%)
- **Academic professionals**:
  Price (55.78%) environmental impact (56.46%), performance (51.70%).
- **Business, self-employed and healthcare professionals**:
  Performance (52.81%), fuel economy (42.70%), price (41.57%)

In summary, **it is observed that price and performance are among the most significant factors for buying EVs across different professionals.** Other major factors determined were the cost to run, fuel economy and the environmental impact.

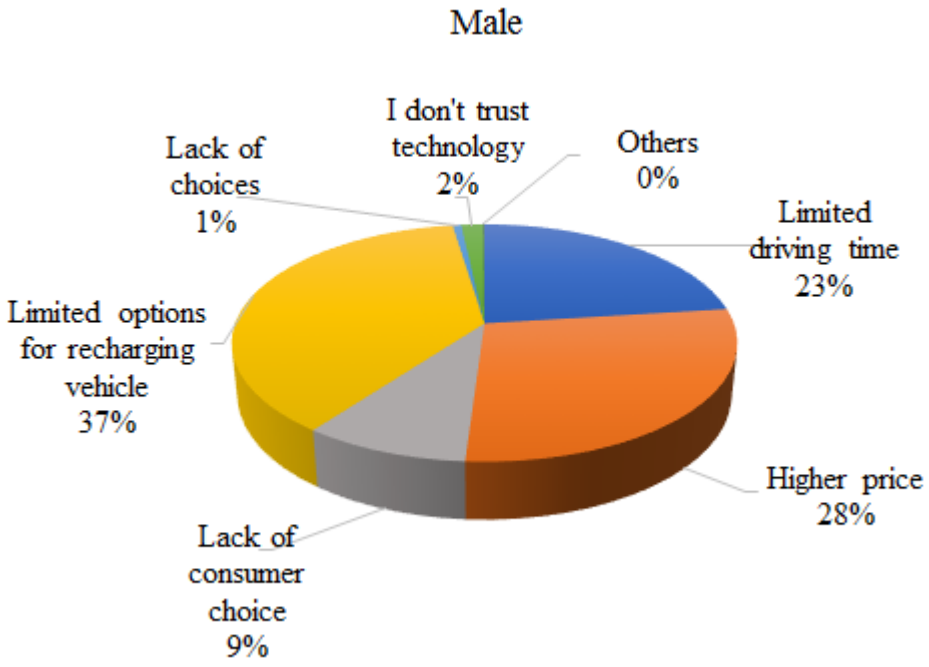
9 Factors Downcasting Electric Vehicle Procurement

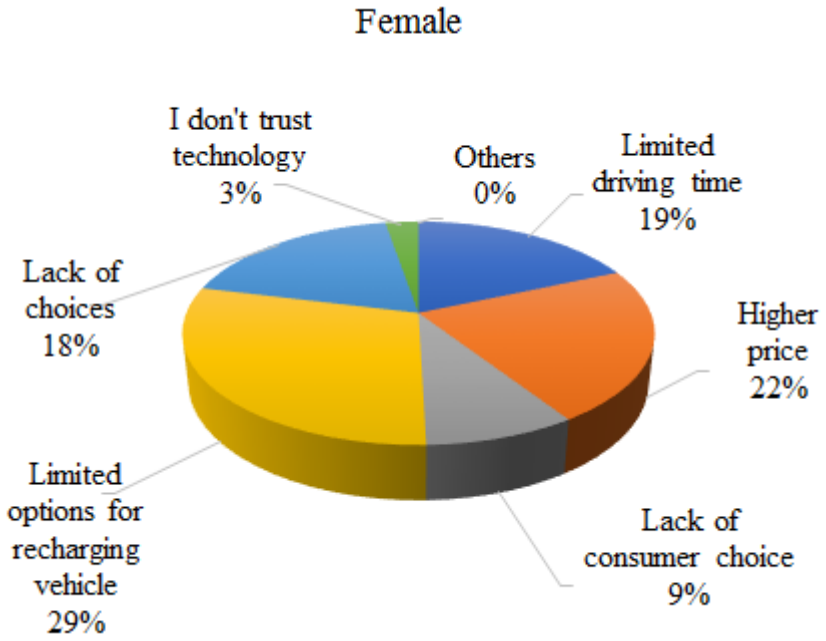
To improve the market share of EVs, one must know the factors that deter individuals from buying EVs and understand factors considered while buying EVs. **In general, limited options for recharging the EVs are the single most major discouraging factor across gender, age groups, highest educational level, and occupation, except farmers/ agriculturists, most of whom consider price a significant setback to buying EVs.** Higher prices, limited driving time, and lack of choice are the other major discouraging factors in general. A small fraction of individuals has also selected “I don’t trust the technology,” which suggests the need for awareness campaigns to address the hesitations and mitigate misconceptions.

9.1 What factors discourage you when buying an Electric Vehicle?

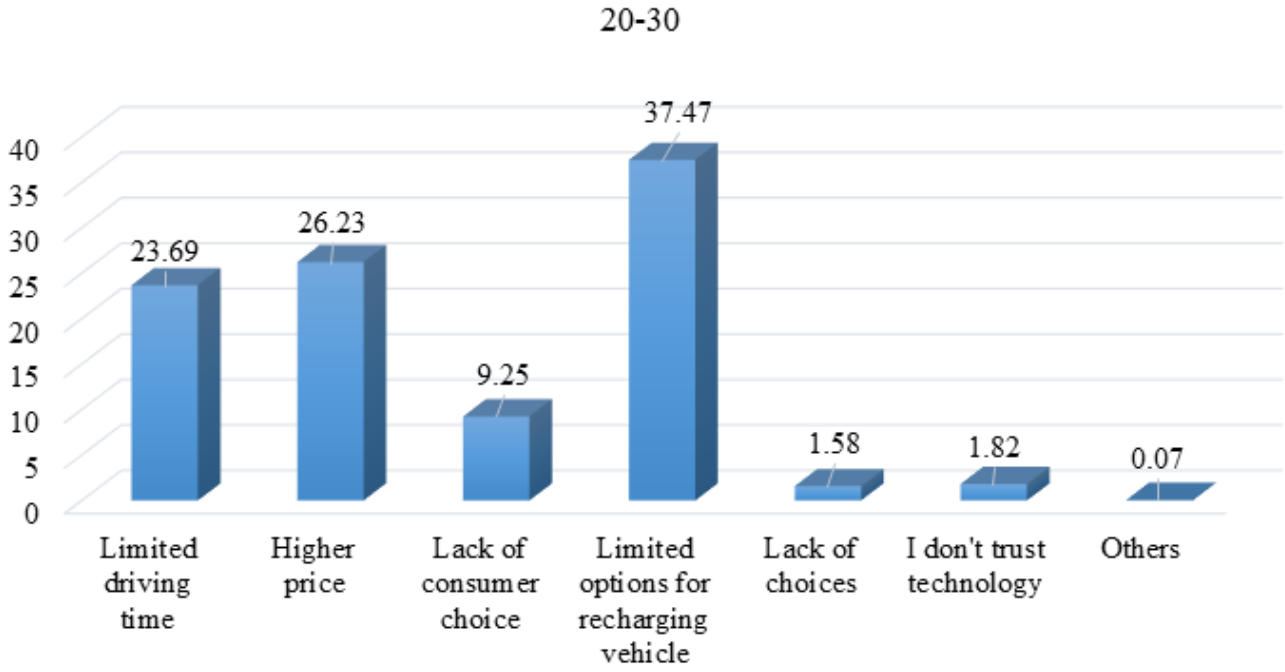
Few general factors which discourage individuals from investing in procuring EVs are determined. These factors mostly compare the EVs and ICE-based vehicles. **The factors are a limited driving range, higher price, lack of consumer choices, lack of charging infrastructure, lack of options in variants of EVs, and trust in the newer technologies.**

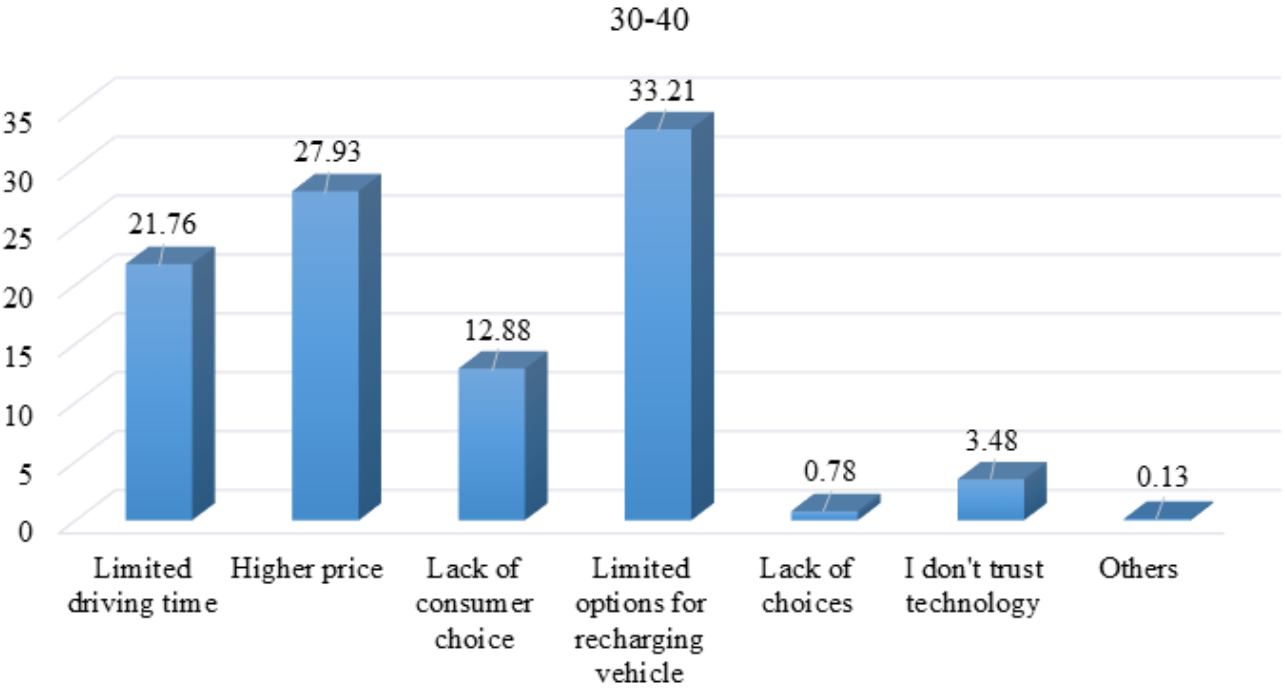
9.1.1 Gender

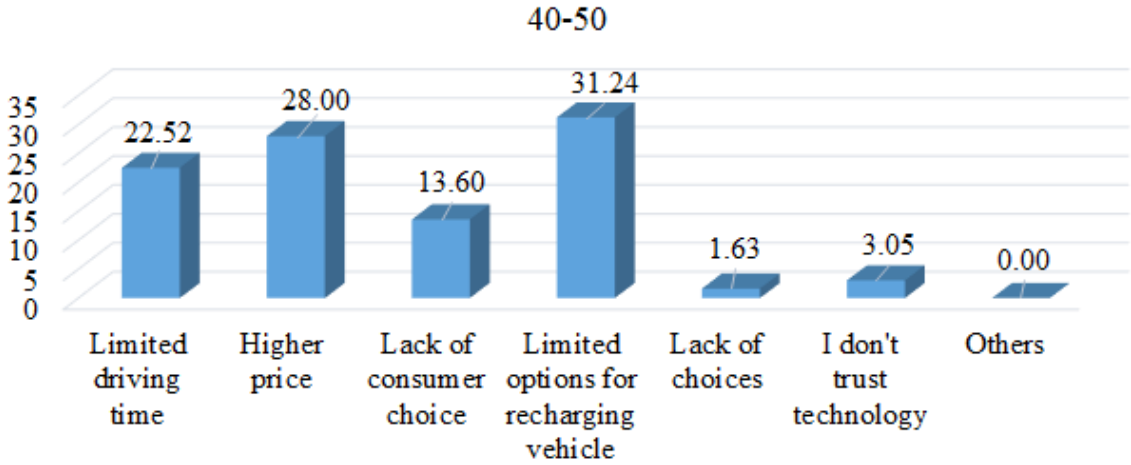


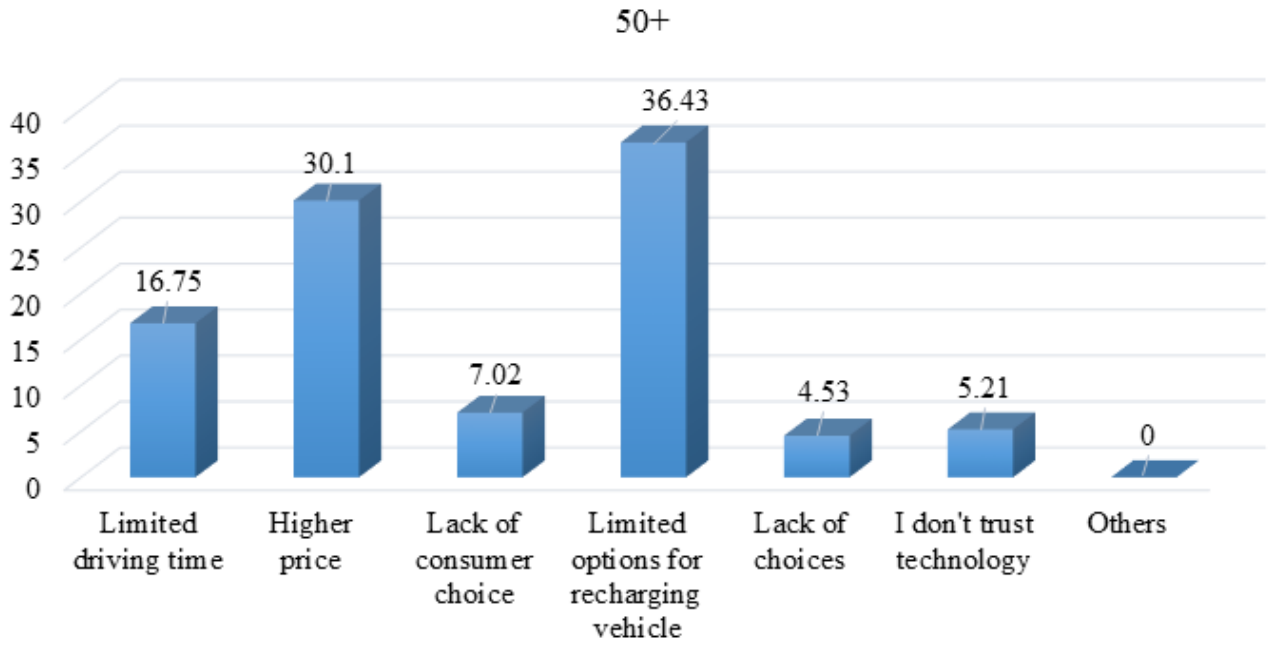


9.1.2 Age

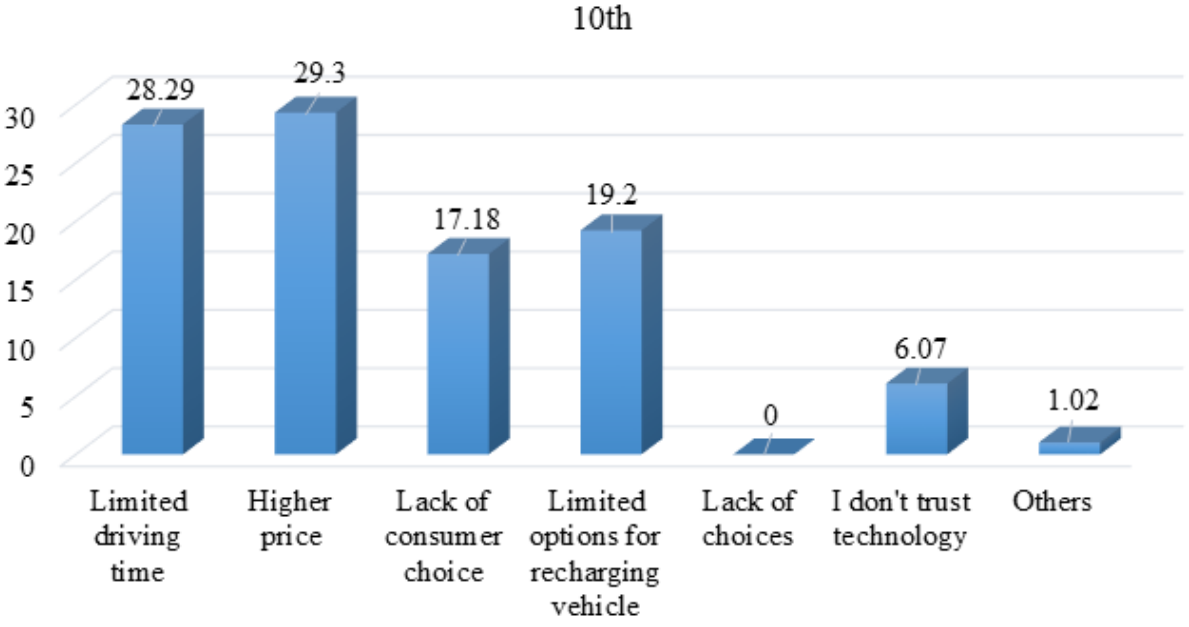

20-30
40
35
30
25
20
15
10
5
0
23.69
26.23
9.25
37.47
1.58
1.82
0.07
Limited driving time
Higher price
Lack of consumer choice
Limited options for recharging vehicle
Lack of choices
I don't trust technology
Others

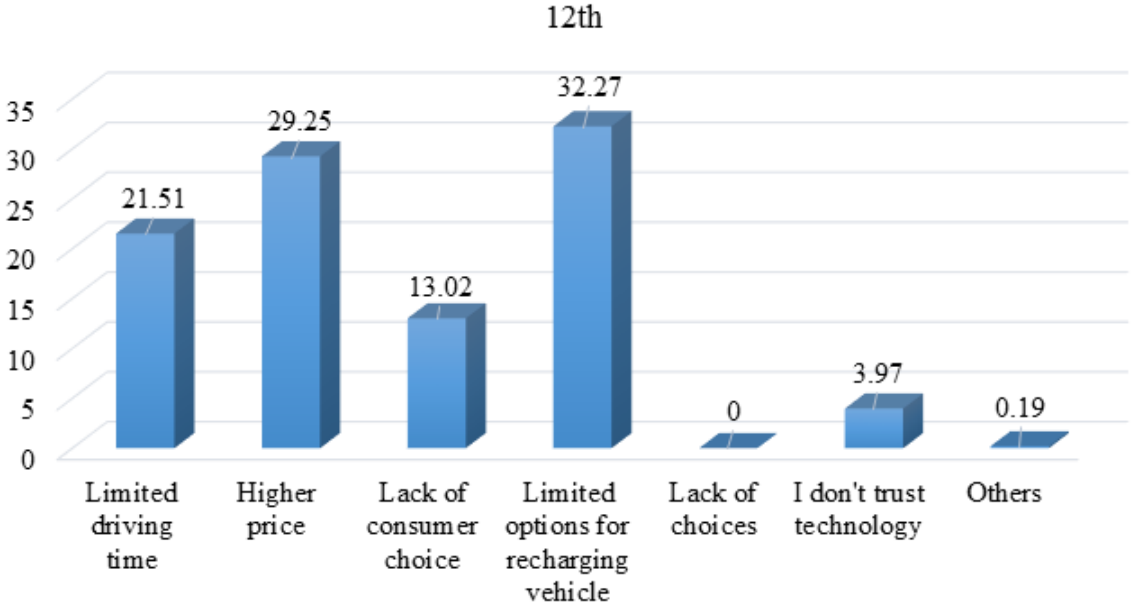

30-40
35
30
25
20
15
10
5
0
21.76
27.93
12.88
33.21
0.78
3.48
0.13
Limited driving time
Higher price
Lack of consumer choice
Limited options for recharging vehicle
Lack of choices
I don't trust technology
Others

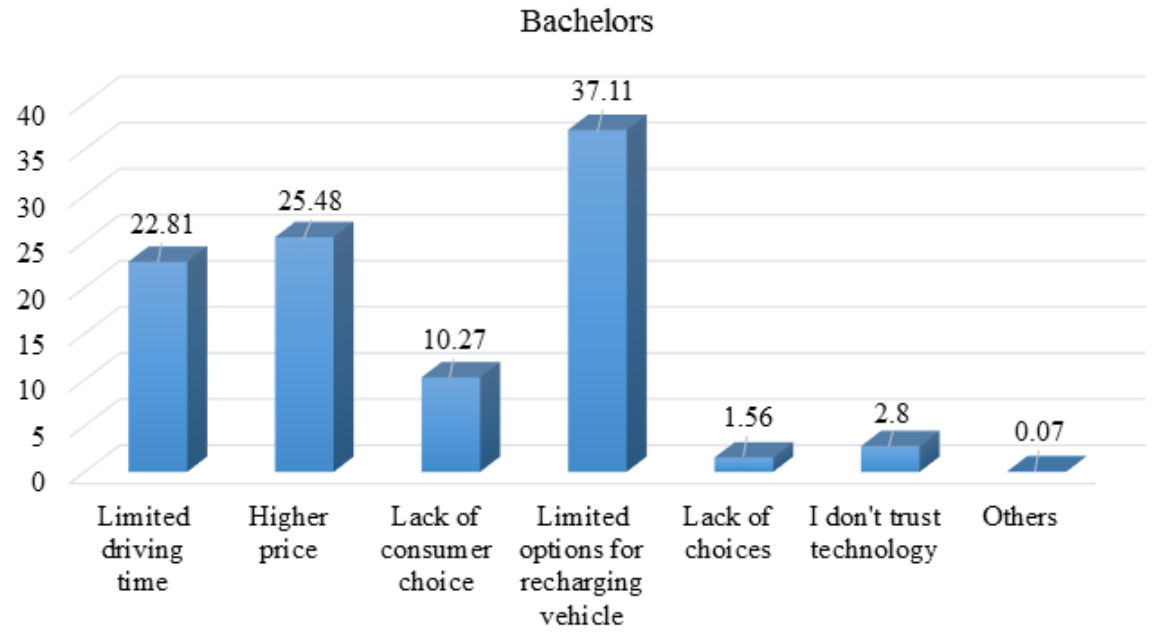

40-50
35
30
25
20
15
10
5
0
22.52
28.00
13.60
31.24
1.63
3.05
0.00
Limited driving time
Higher price
Lack of consumer choice
Limited options for recharging vehicle
Lack of choices
I don't trust technology
Others

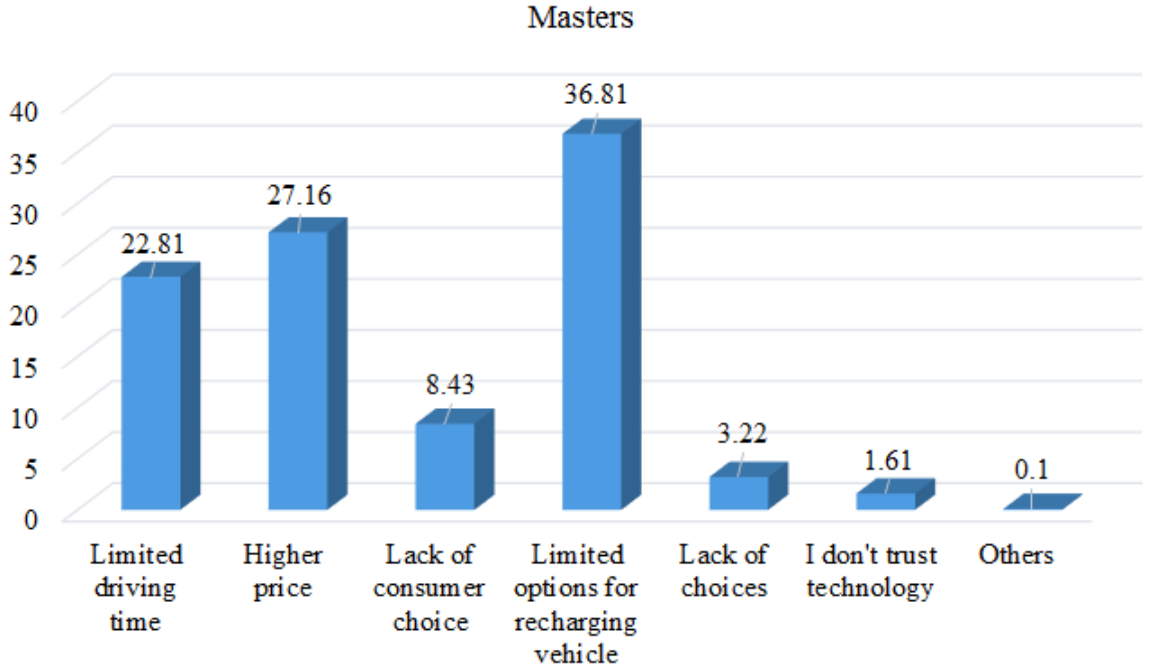


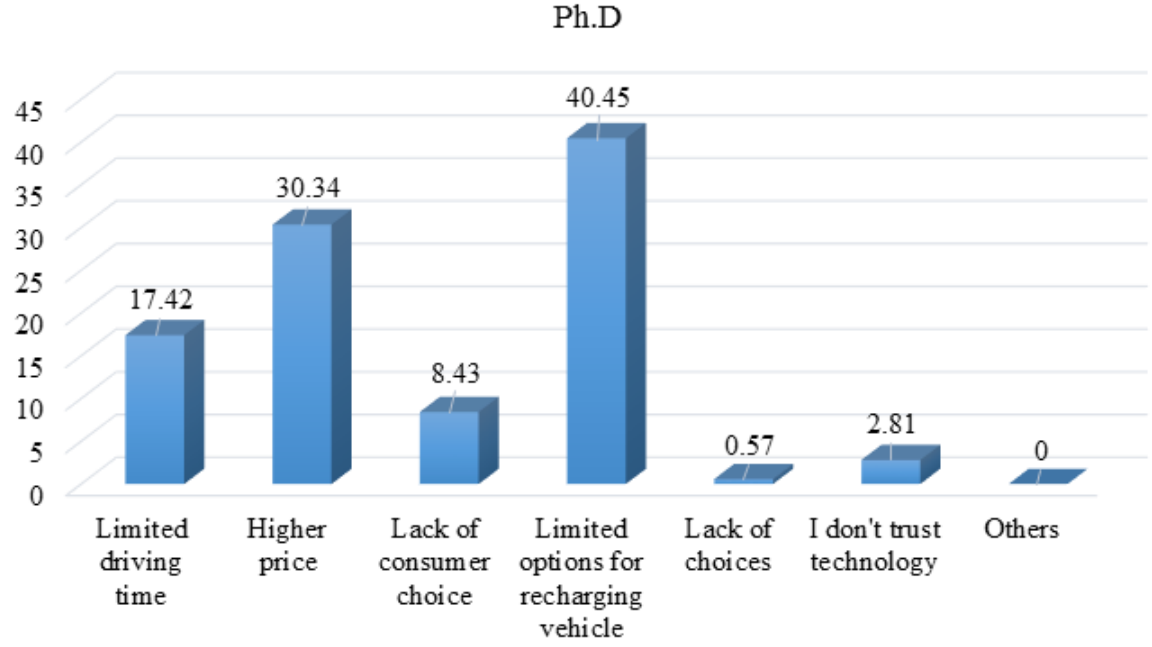
9.1.3 Education Qualification



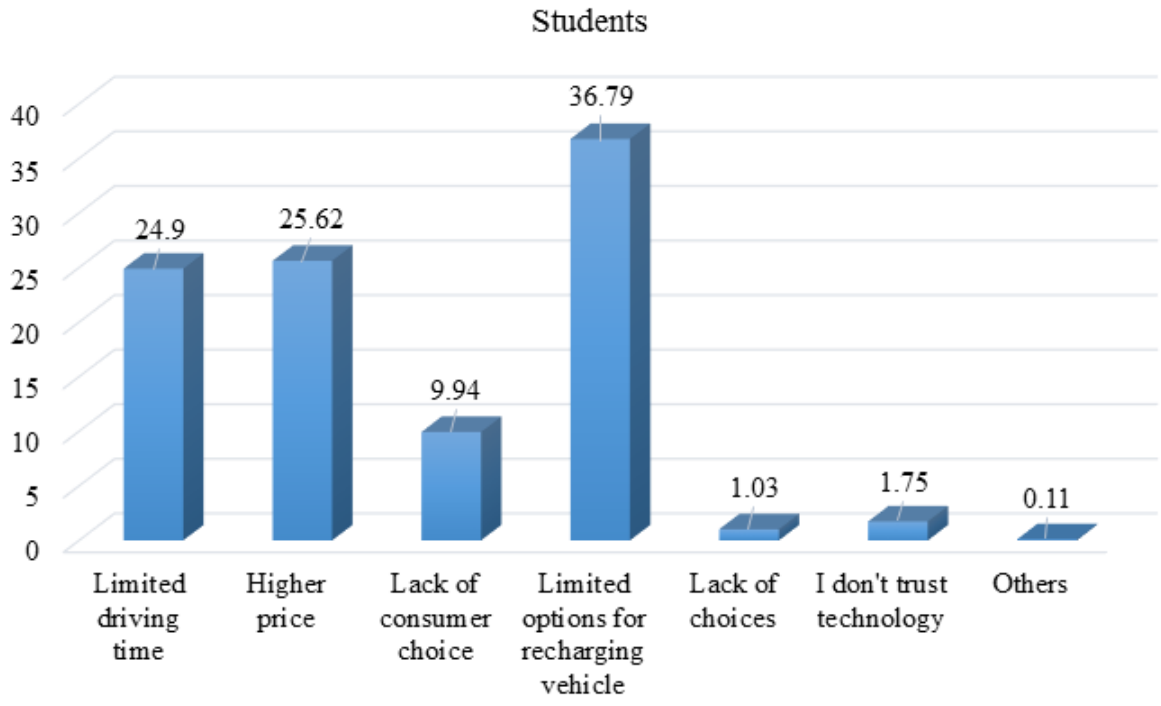


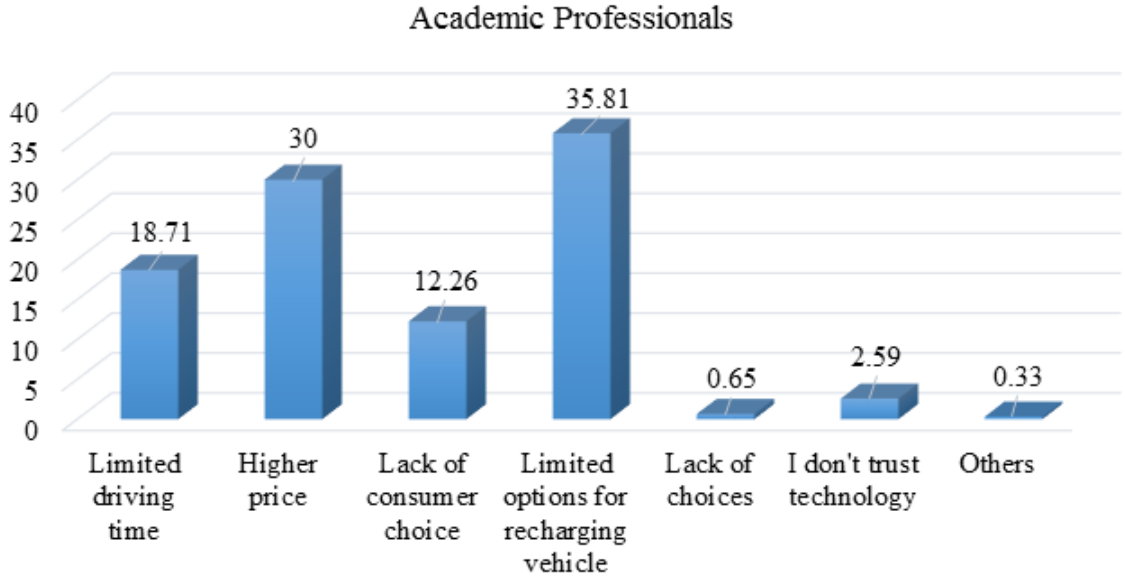

Bachelors
40
35
30
25
20
15
10
5
0
22.81
25.48
10.27
37.11
1.56
2.8
0.07
Limited driving time
Higher price
Lack of consumer choice
Limited options for recharging vehicle
Lack of choices
I don't trust technology
Others

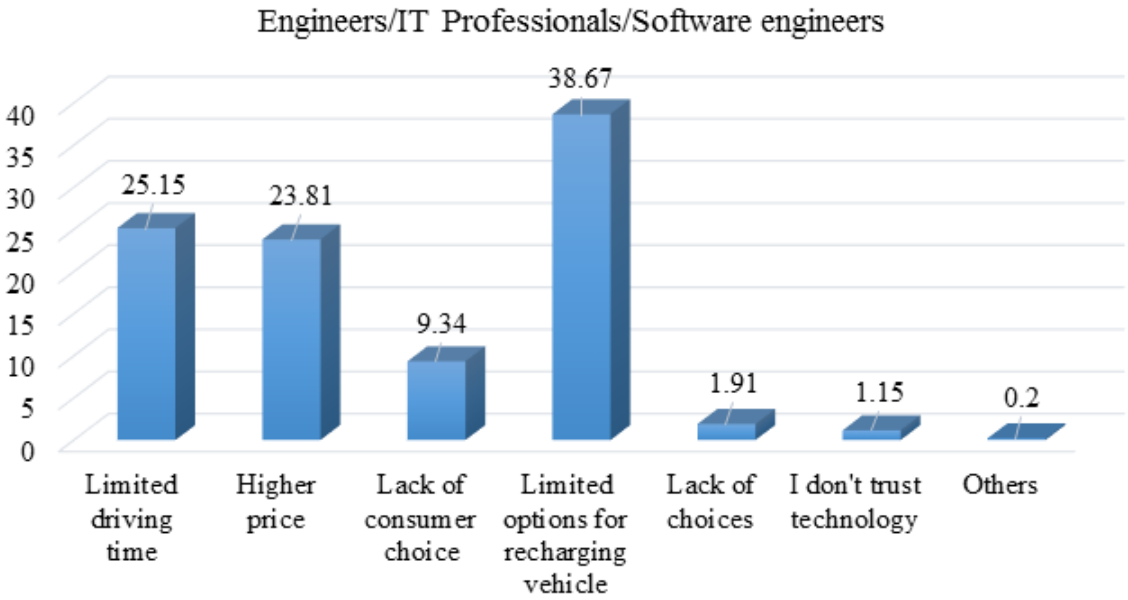

Masters
40
35
30
25
20
15
10
5
0
22.81
27.16
8.43
36.81
3.22
1.61
0.1
Limited driving time
Higher price
Lack of consumer choice
Limited options for recharging vehicle
Lack of choices
I don't trust technology
Others

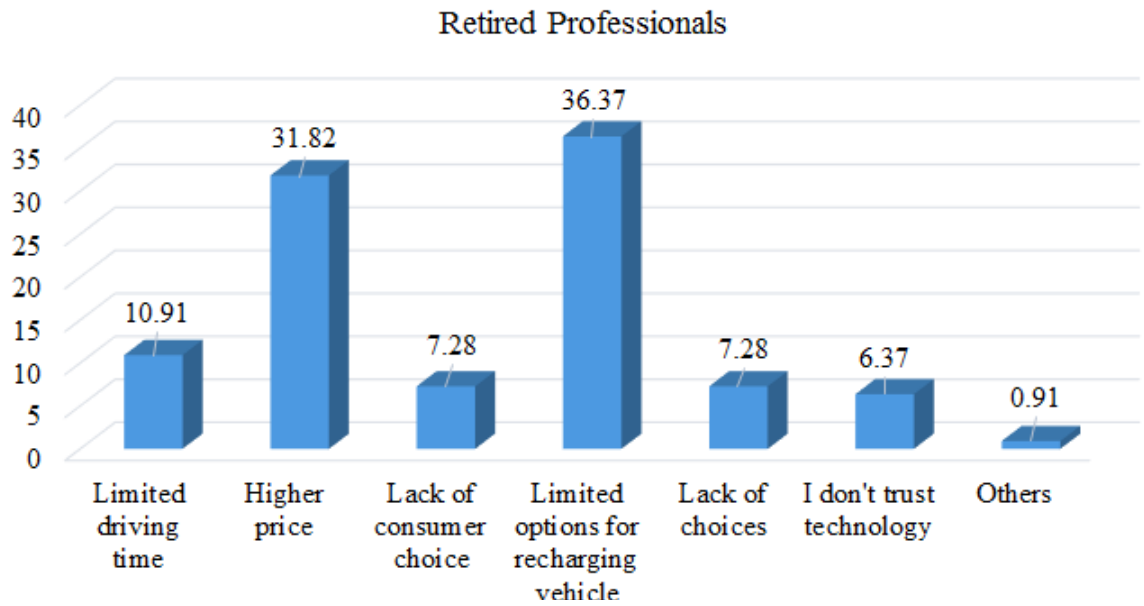

Ph.D
45
40
35
30
25
20
15
10
5
0
17.42
30.34
8.43
40.45
0.57
2.81
0
Limited driving time
Higher price
Lack of consumer choice
Limited options for recharging vehicle
Lack of choices
I don't trust technology
Others

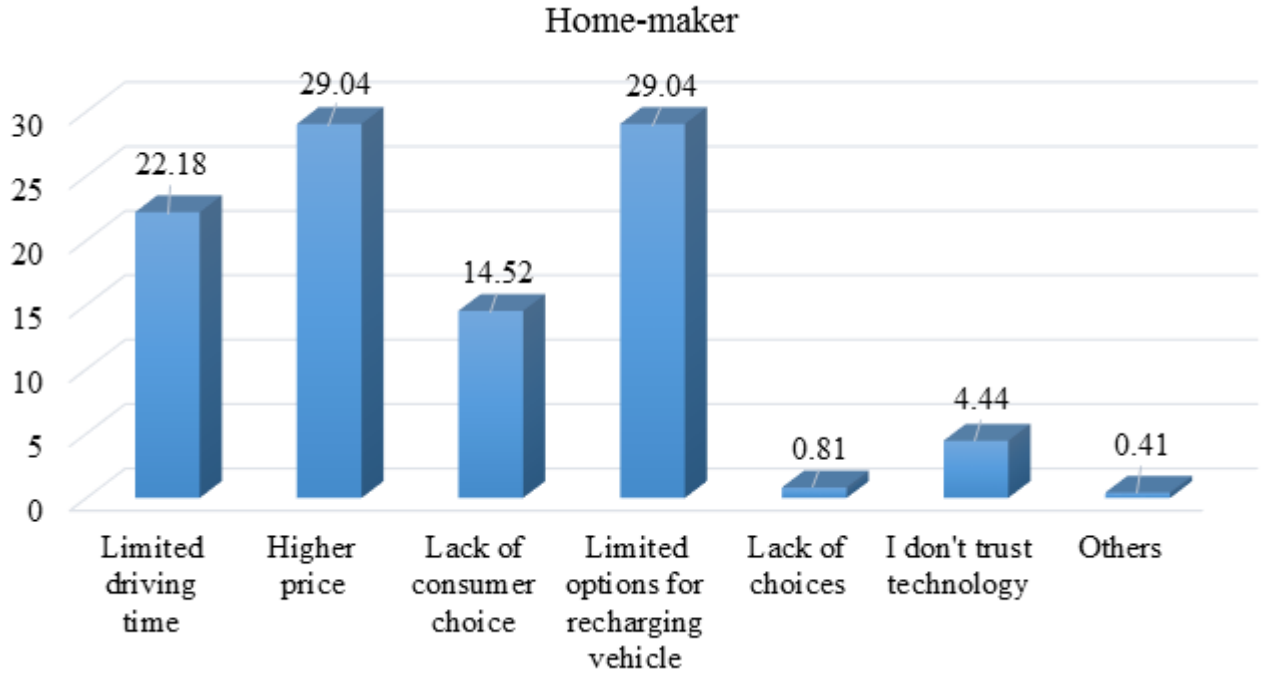
9.1.4 Occupation



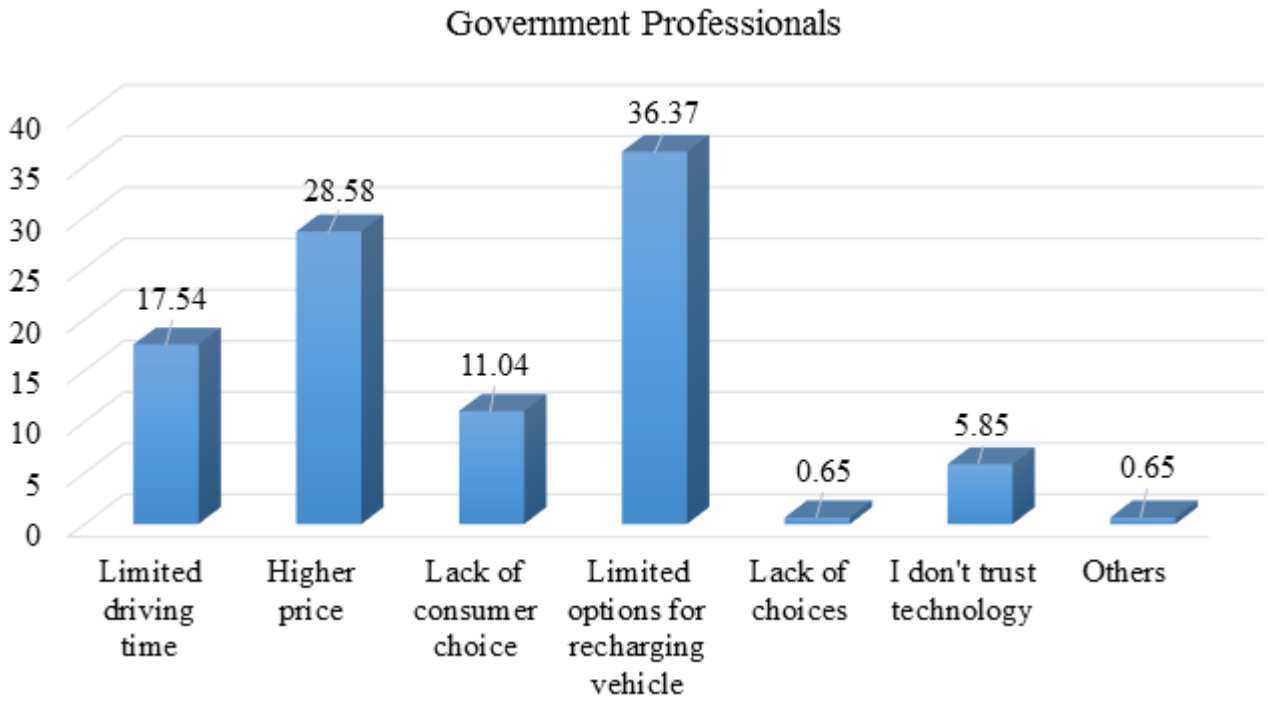


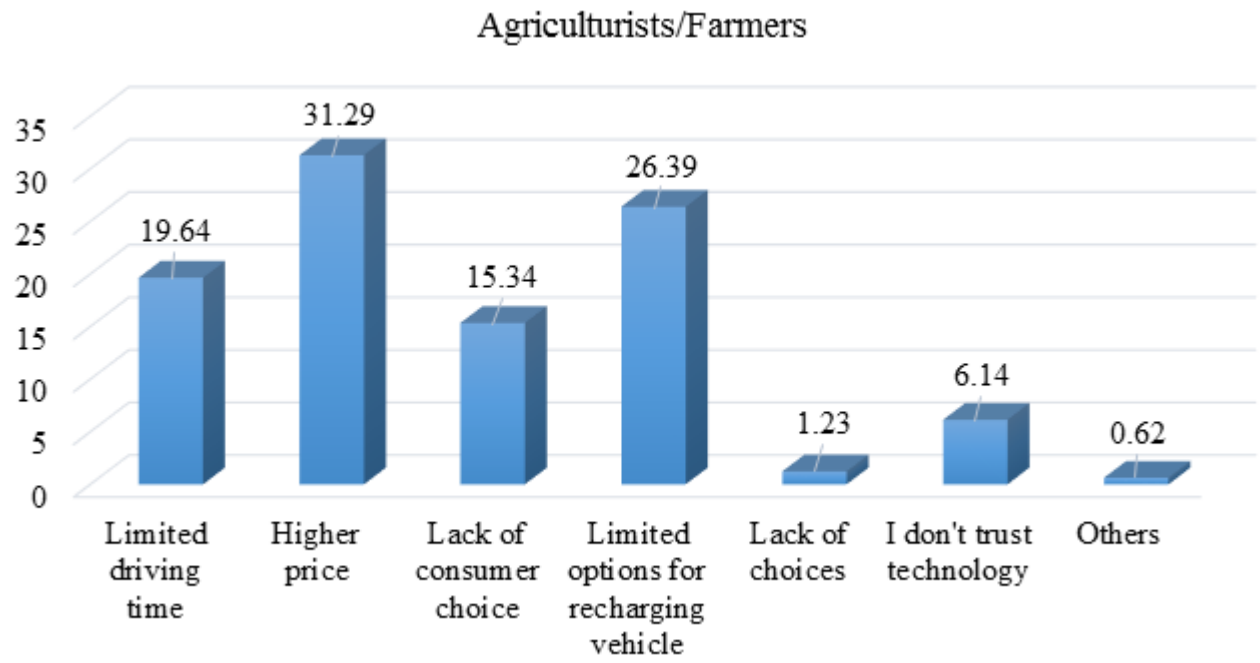



Retired Professionals
40
35
30
25
20
15
10
5
0
10.91
31.82
7.28
36.37
7.28
6.37
0.91
Limited driving time
Higher price
Lack of consumer choice
Limited options for recharging vehicle
Lack of choices
I don't trust technology
Others


Home-maker
30
25
20
15
10
5
0
22.18
29.04
14.52
29.04
0.81
4.44
0.41
Limited driving time
Higher price
Lack of consumer choice
Limited options for recharging vehicle
Lack of choices
I don't trust technology
Others


Business Professionals/Self Employed/Health Care
35
30
25
20
15
10
5
0
20.42
29.5
10.13
34.91
2.27
2.8
0.18
Limited driving time
Higher price
Lack of consumer choice
Limited options for recharging vehicle
Lack of choices
I don't trust technology
Others





9.2 Insight and Analysis

1. **Regardless of gender, educational qualification, and occupation, "limited options for recharging vehicles" is determined as a major discouraging factor.** The recharging of EVs has a variety of challenges that are specific to India. These include a lack of space to park vehicles while recharging. **A longer recharging time further adds to the challenge.** As a user of ICE-based vehicles, the EV users expect a similar refueling pace while recharging batteries in EVs. Further, time to recharge, infrastructure requirements, and accelerated battery degradation due to fast charging are common challenges in India, including worldwide.

2. Another aspect while looking into the plots of gender and the factors deterring the purchase of EVs, **"lack of consumer choices"** is a significant concern as conveyed by the female respondents. The lack of consumer choices **refers to the variations in color, model types, range of prices, and functionalities.**
3. Majority of the survey respondents considered **"limited options for recharging vehicles"** and **"higher price"** as significant factors that discourage the purchase of EVs.
4. Trust to the technology or reliability and safety are other challenges inferred from the survey, especially from individuals above 50 years. **Although the percentage is small, yet lack of trust in technology should not be neglected.**
5. The educational qualification-based plots inferred that **"limited options for recharging vehicles" is one of the prominent discouraging factors.** However, the individuals with academic qualifications upto the secondary school level considered "limited driving time" and "higher price" the most discouraging factors.
6. In general, irrespective of age, gender, qualification, and occupation, **limited driving time, higher price, and limited options for recharging are considered to be the most significant discouraging factors.**
7. Following were some of the most critical factors for people from different professional backgrounds. The percentage value mentioned in the brackets represents the choice of individuals from various professional backgrounds expressed as a percentage of total individuals belonging to the same background.
   - **Students**:
     a. limited options for recharging vehicles (36.79%)
     b. limited driving time (24.9%)
     c. higher price (25.62%)
   - **Farmers/ agriculturists**:
     a. higher price (31.29%)
     b. limited options for recharging vehicles (26.39%)
   - **Retired professionals**:a. limited options for recharging vehicles (36.37%)
     b. higher price (31.82%)
   - **Homemakers**:
     a. limited options for recharging vehicles (29.04%)
     b. higher price (29.04%)
   - **Engineers and IT professionals**:
     a. limited options for recharging vehicles (38.67%)
     b. limited driving time (25.15%)
   - **Government professionals**:
     a. limited options for recharging vehicles (36.67%)
     b. higher price (28.58%)
   - **Academic professionals**:
     a. limited options for recharging vehicles (35.81%)
     b. higher price (30.00%)
   - **Business, self-employed and healthcare professionals**:
     a. limited options for recharging vehicles (34.91%)
     b. higher price (24.50%)

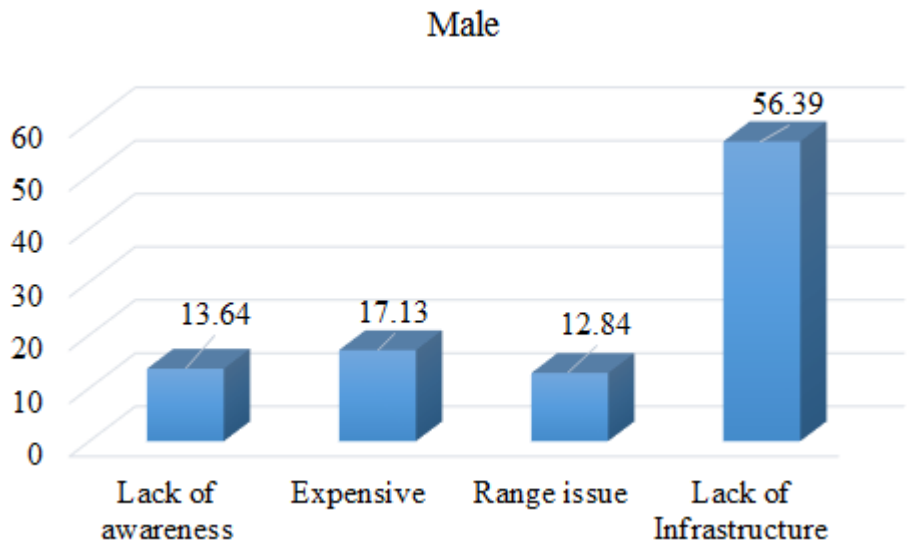
8. **The analysis on the occupation based opinions on the factors deferring the purchase of EVs varies widely.** The analysis on the opinions are given below:
   - "limited options for recharging vehicles" is the only significant factor for most students, engineers and IT professionals, and professionals other than those listed in the survey form.
   - The majority of farmers and agriculturists consider both "higher price" and "limited driving time" as important factors that discourage them from buying an EV.
   - Among retired professionals, a small population considers "lack of choices" and "lack of consumer choices" as discouraging factors.
   - Similarly, "limited options for recharging vehicles" are considered essential by many government professionals, academic professionals, and business/self-employed/healthcare professionals.

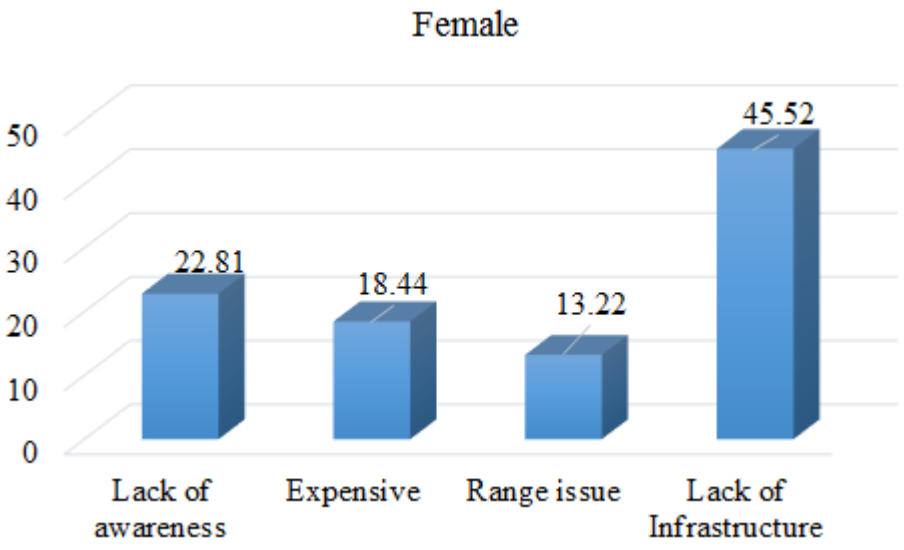
10 Road-blocks in Electric Vehicle Adaption

The previous sections pointed towards price, performance, lack of charging options, and awareness as the major deciding factors in EV purchase. However, the key factors that require immediate attention for the successful adaption of EVs are not discussed. This section attempts to gain deeper insights into the **influence of each of these factors based on gender, age, educational qualification, and occupation.** The questionnaire listed a few challenges that were determined as points taken into consideration while building ideas for purchasing EVs as an individual. **These challenges are lack of infrastructure, driving range, battery recharging issue, expensive technology, and lack of awareness or trust in the technology.**

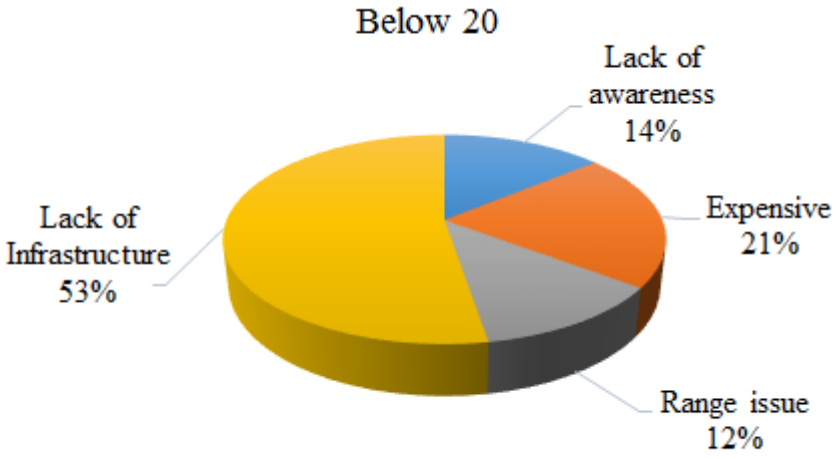
10.1 What are the causes for the delay happening in EV adaption?

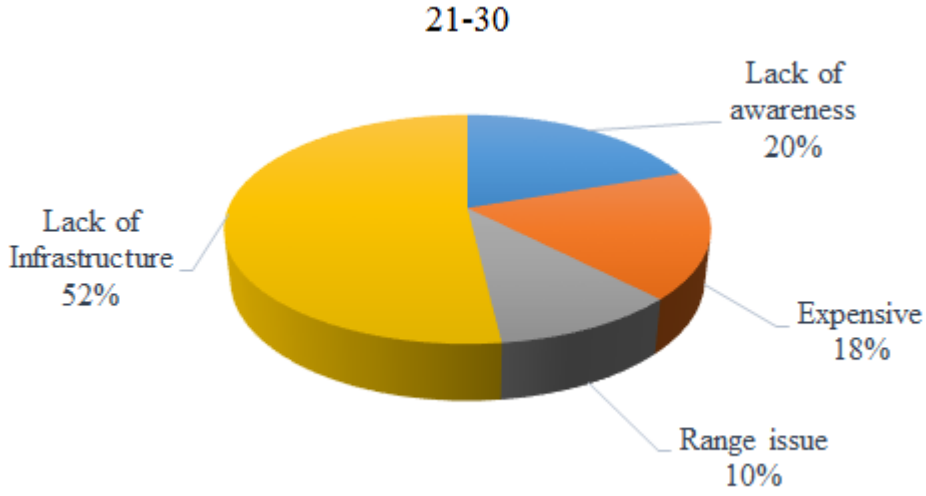
10.1.1 Gender

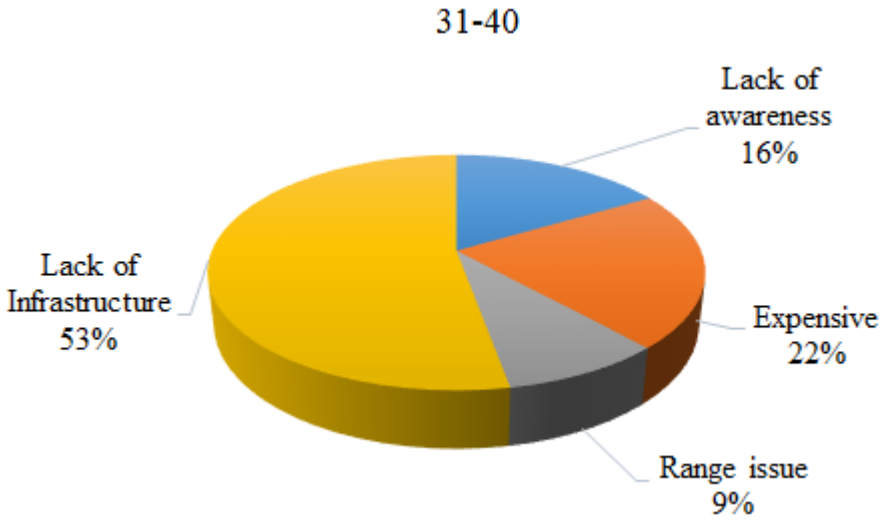


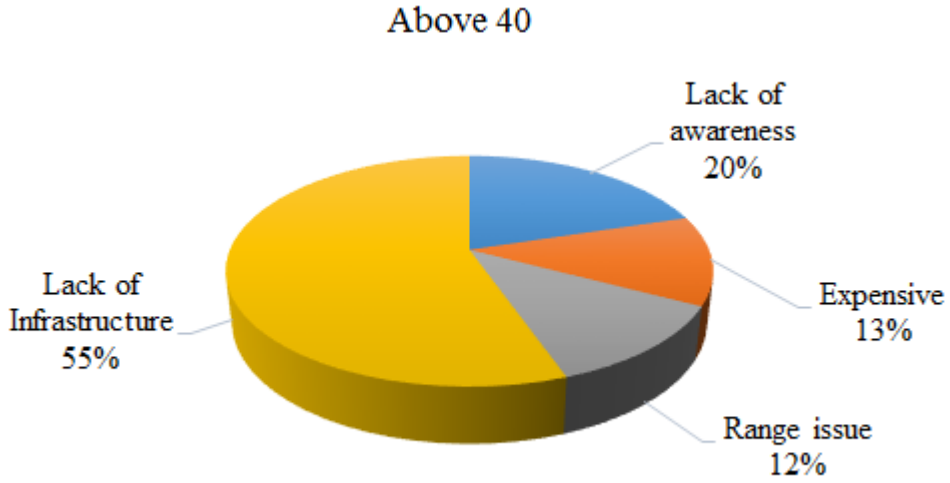

Female
50
40
30
20
10
0
22.81
18.44
13.22
45.52
Lack of awareness
Expensive
Range issue
Lack of Infrastructure

10.1.2 Age

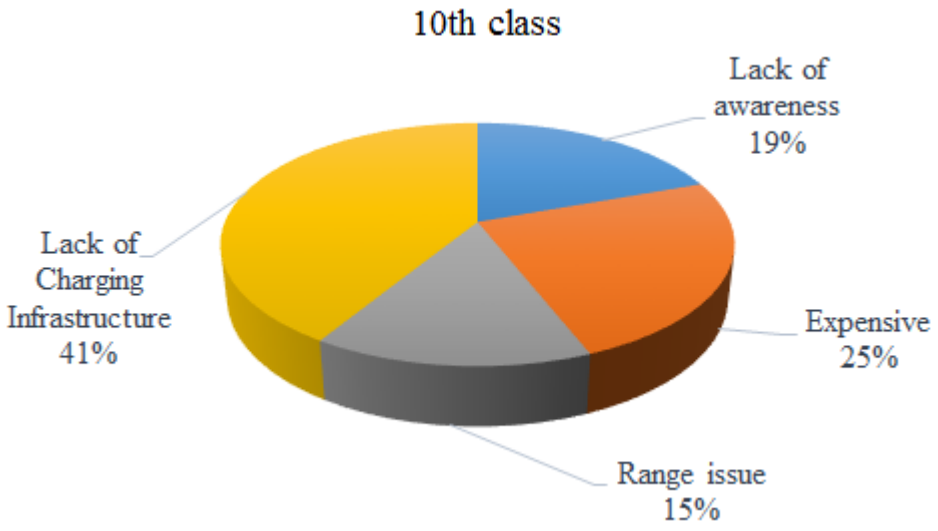

Below 20
Lack of awareness 14%
Expensive 21%
Range issue 12%
Lack of Infrastructure 53%


21-30
Lack of awareness 20%
Expensive 18%
Range issue 10%
Lack of Infrastructure 52%

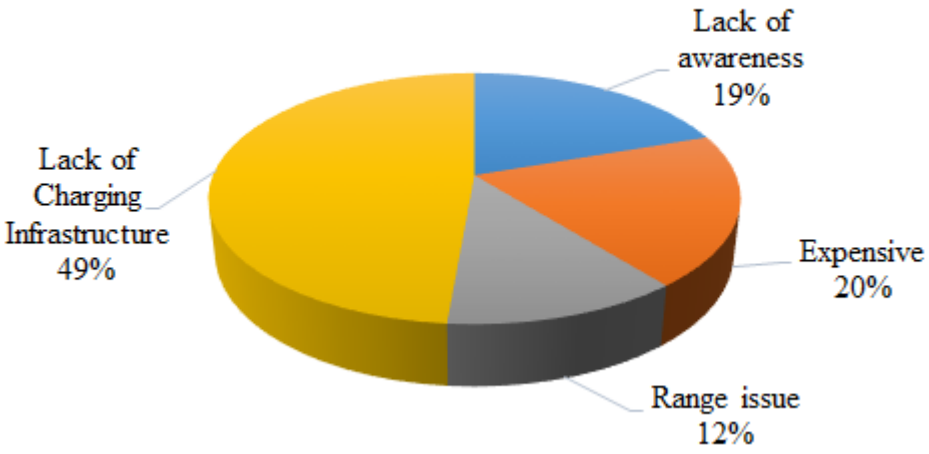




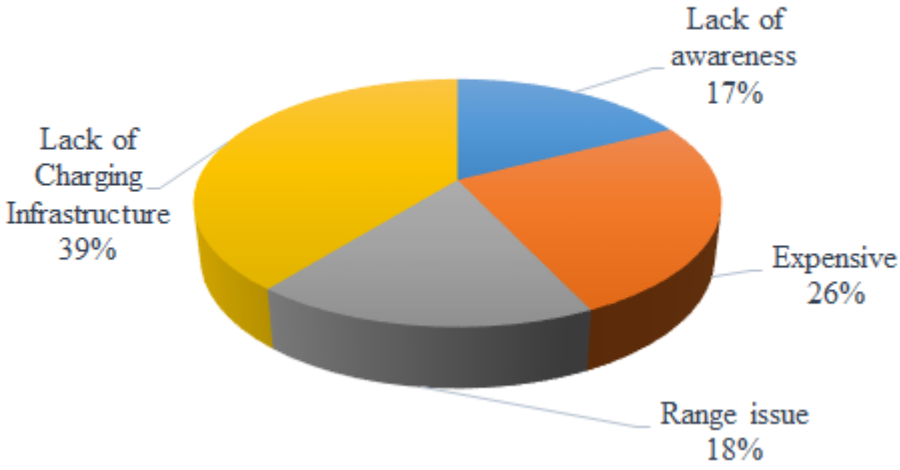
10.1.3 Educational Qualification



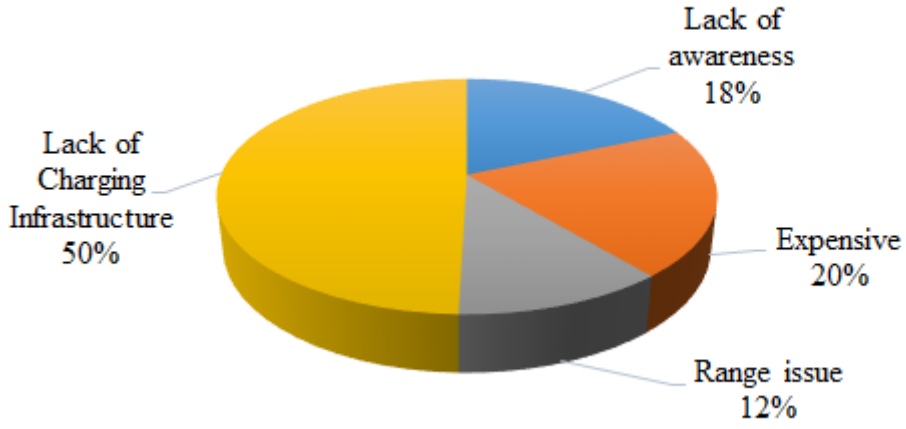
12th



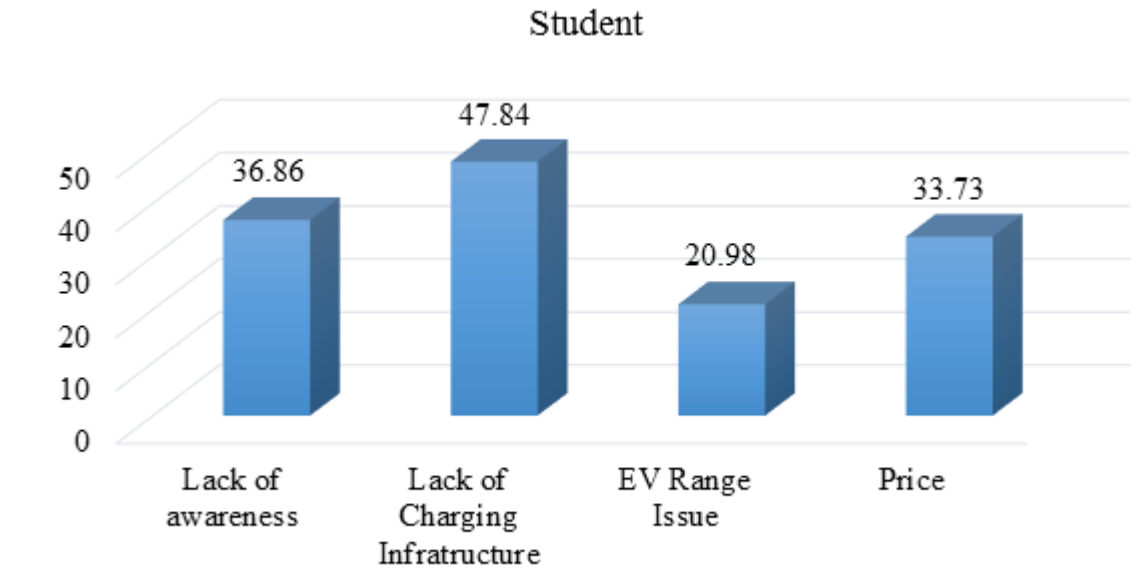
Bachelor

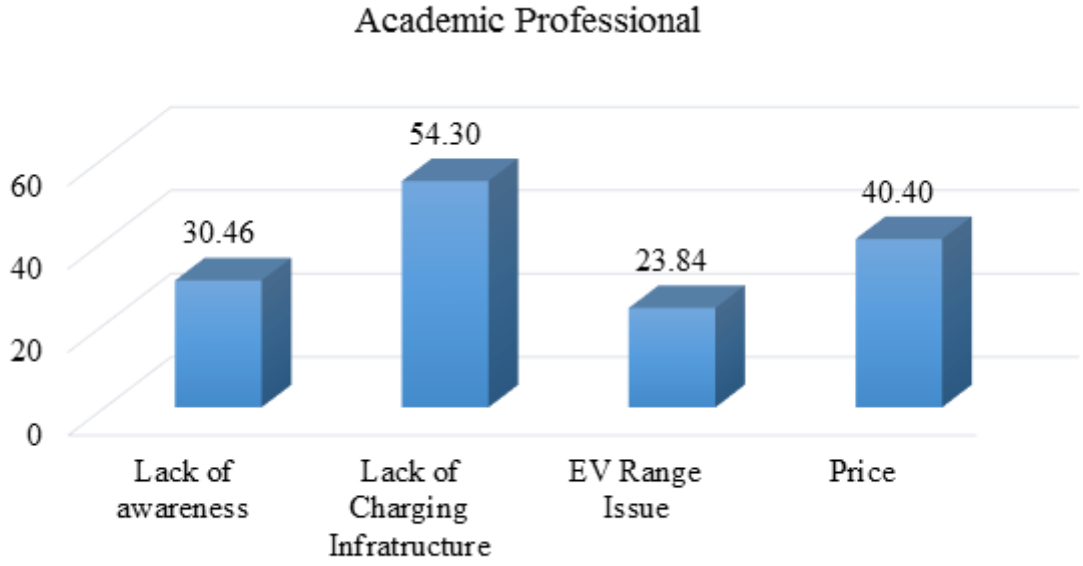


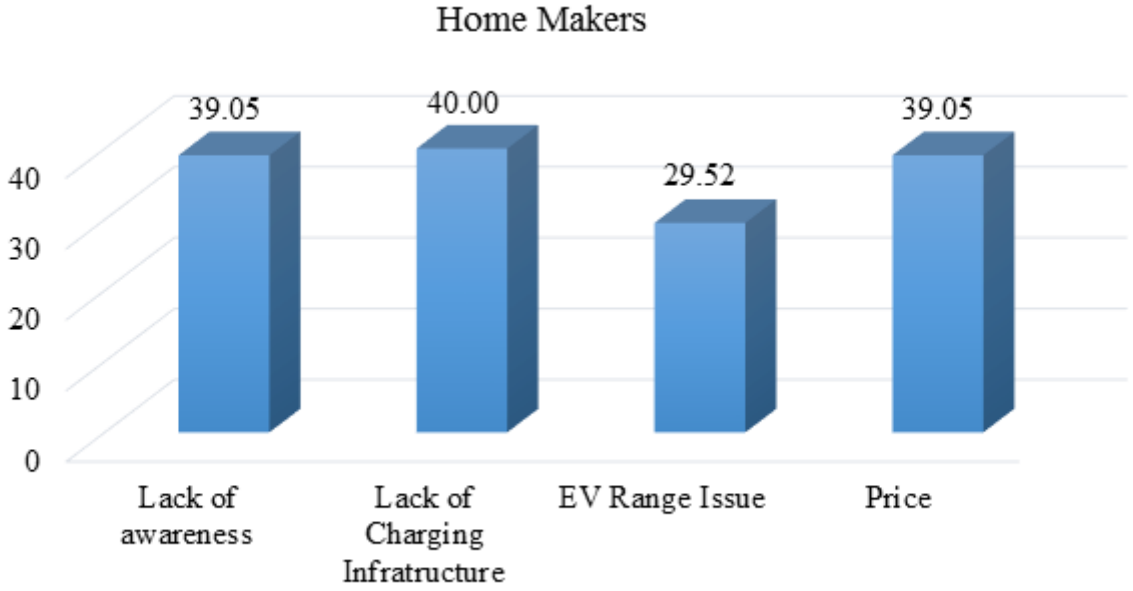
Masters & Ph.D

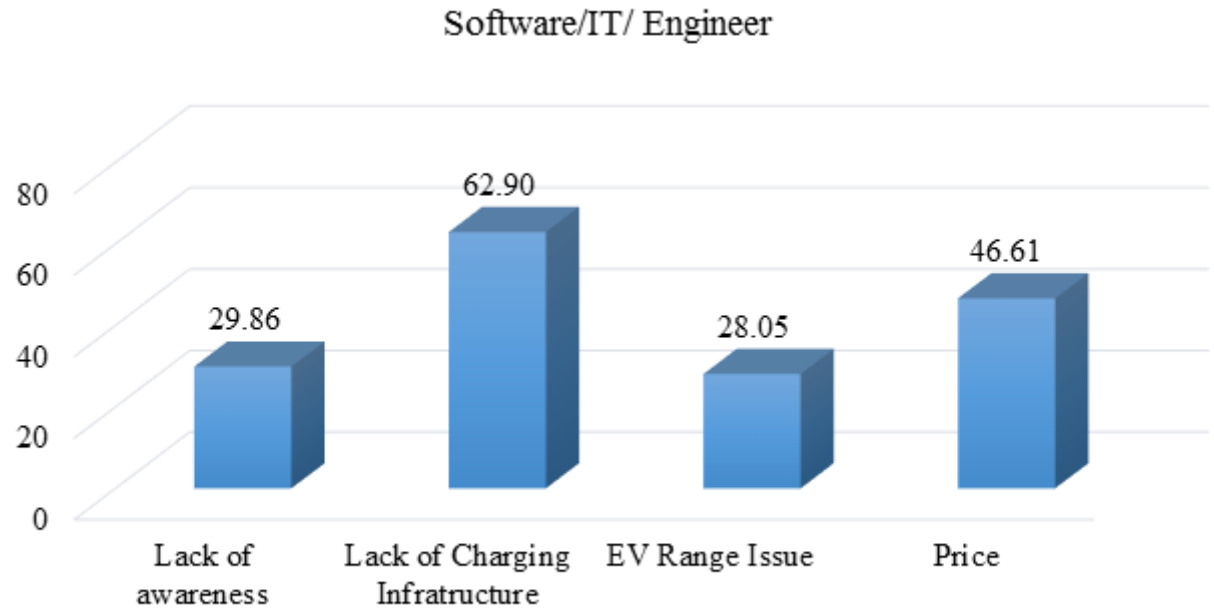


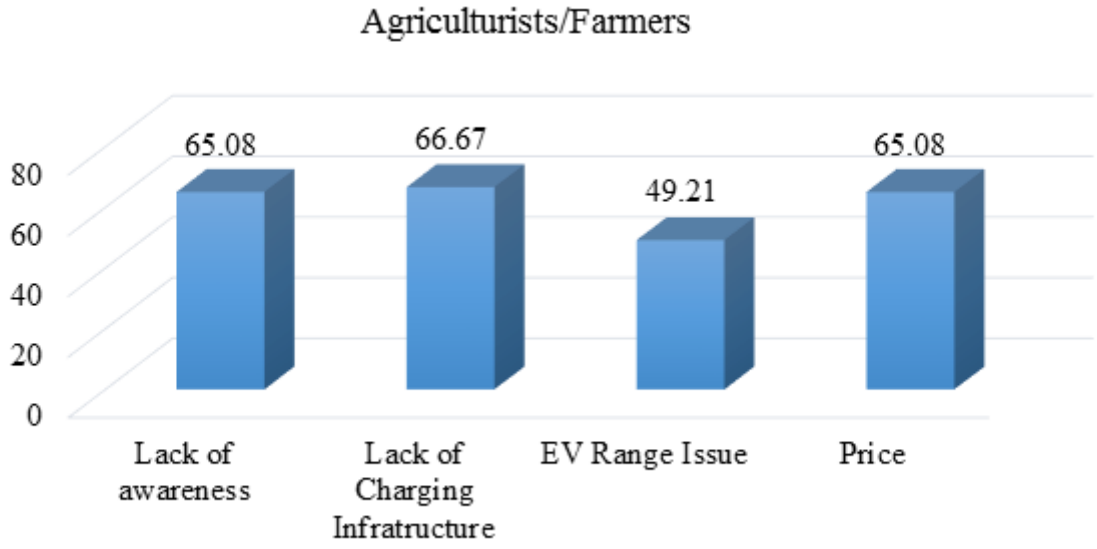
10.1.4 Occupation

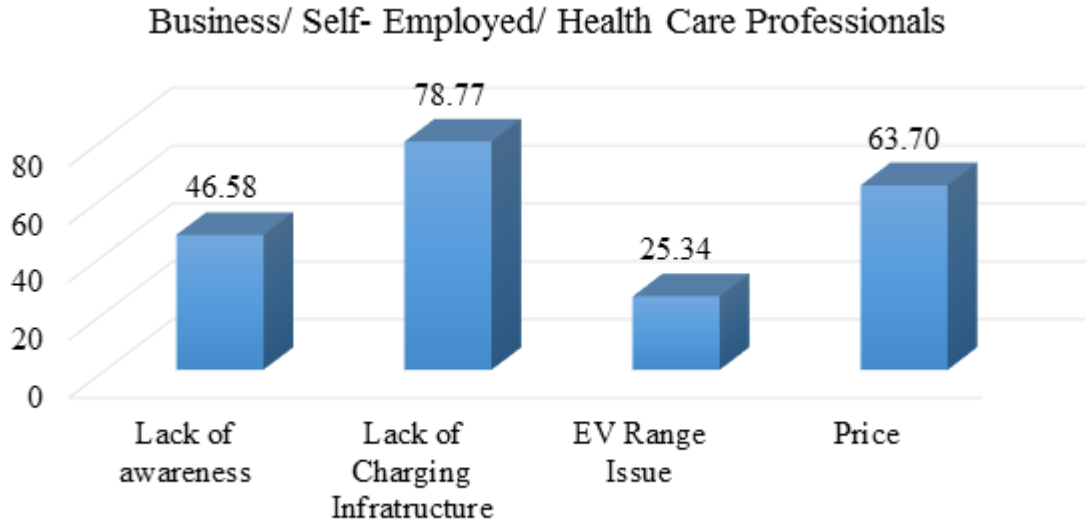


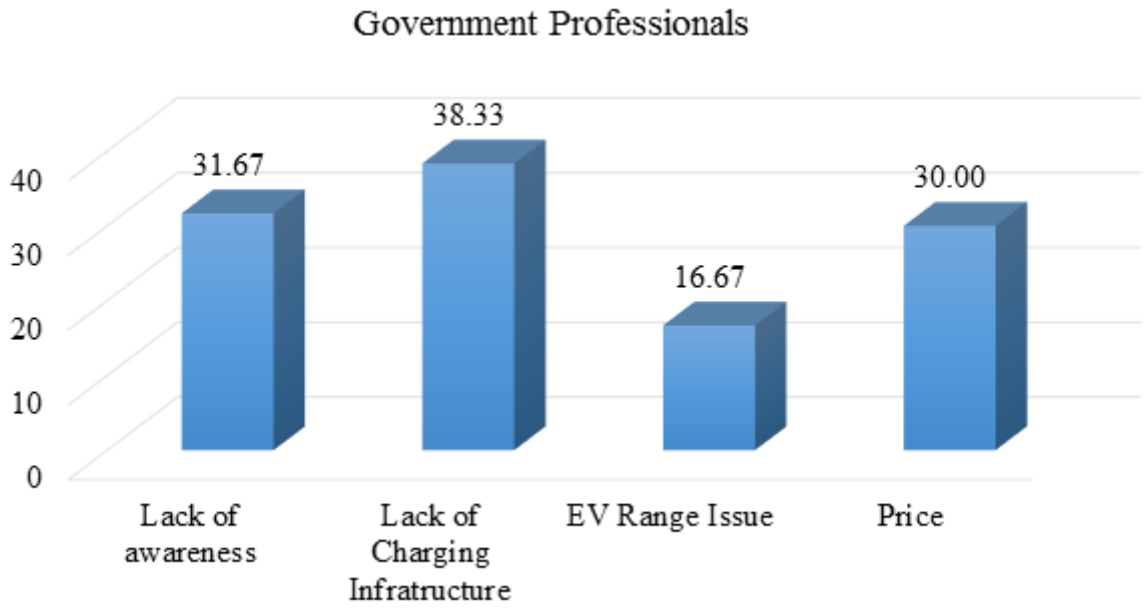


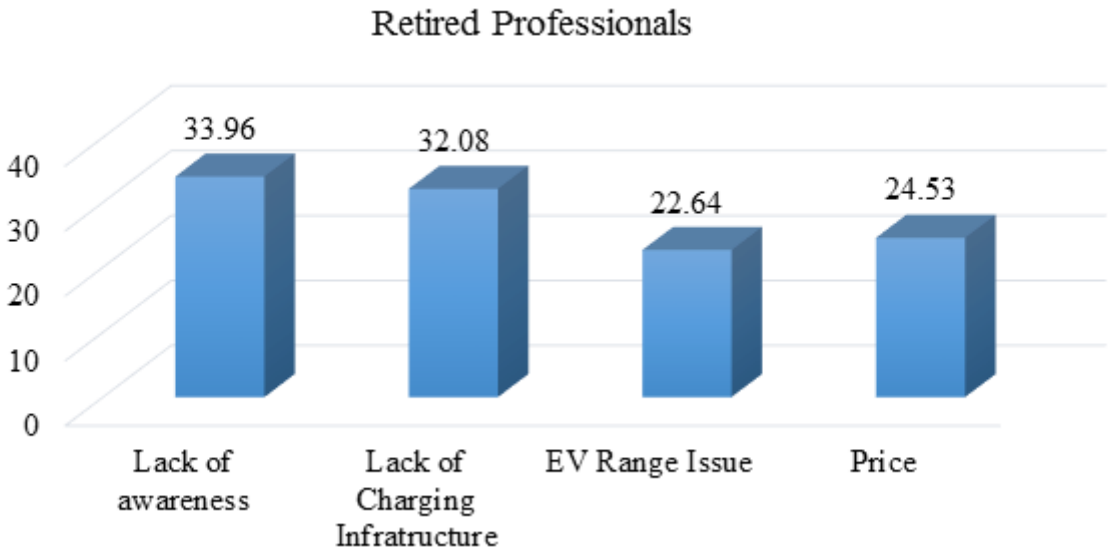



Software/IT/ Engineer
80
60
40
20
0
29.86
62.90
28.05
46.61
Lack of awareness
Lack of Charging Infratructure
EV Range Issue
Price


Agriculturists/Farmers
80
60
40
20
0
65.08
66.67
49.21
65.08
Lack of awareness
Lack of Charging Infratructure
EV Range Issue
Price


Business/ Self- Employed/ Health Care Professionals
80
60
40
20
0
46.58
78.77
25.34
63.70
Lack of awareness
Lack of Charging Infratructure
EV Range Issue
Price





10.2 Insights and Analysis

1. The gist of factors which are causing the delay in EV adaption in terms of percentage is given below:
   - **Lack of Charging Infrastructure (46%),**
   - **Expensive (20%),**
   - **Lack of awareness (19%),**
   - **Range issue (15%)**
2. The requirement of an EV charging infrastructure and technologies or algorithms to fast charge remains a significant challenge for ensuring more rapid adaption of EVs. **According to the inputs from the respondents of the survey, 45.52% female and 56.39% male thinks that lack of charging infrastructure is a significant problem.** In general, any technology which relies on a specific type of fuel must ensure ease in availability of fuel to ensure faster adaption. ICE-based vehicles are popular

not only because of the level of maturity, the availability, and the cost of fuel also have an essential role in setting the preference to purchase by an individual.

The inference further extends to the efficiency of the powertrain and the cost of recharging batteries of EVs. The efficiency of the powertrain relates to the mileage of vehicles. In contrast, an increase or decrease in the fossil cost relates to the types of battery electrochemistry and preference to invest in EVs. Digging deeper, the cost of the battery changes with the electrochemistry, which determines the rate of charge and discharge or application and size of the battery pack. The battery electrochemistry resembles the types of fuel for ICE-based vehicles -petrol, diesel, or CNG. The ICE-based vehicles' fuel type selection is made based on the types of operation- public or private. Hence, an individual purchasing EVs does not limit the thought to the requirement of recharging infrastructure but extends to the efficiency of power train (impacts range) and time to charge or rate of degradation.

3. The **insights drawn from the different age groups** also state that the **lack of charging infrastructure is a significant cause of the delay in EV adaptation.**
4. When **insights were drawn from the levels of educational qualifications, lack of charging infrastructure remains as the significant challenge** causing the delay in the adaption of EVs.
5. The factors considered by professionals of varied occupations are given below:
   - **Students**
     36.86% felt Lack of awareness, 47.84% felt Lack of Charging Infrastructure, 20.98% felt EV range issue and 33.73% felt price causes for delay happening in the country in EV adaptation.
   - **Academic Professionals**
     30.46% felt Lack of awareness, 54.30% felt Lack of charging infrastructure, 23.84% felt EV range issue and 40.40% felt price causes for delay happening in the country in EV adaptation
   - **Software/IT/Engineers** –
     29.86 % felt Lack of awareness, 62.90% felt Lack of Charging Infrastructure, 28.05% felt EV range issue and 46.61% felt price causes for delay happening in the country in EV adaptation.
   - **Homemakers** –
     39.05 % felt Lack of awareness, 40.00% felt Lack of Charging Infrastructure, 29.52% felt EV range issue and 39.05% felt price causes for delay happening in the country in EV adaptation.
   - **Agricultural Farmers** -
     65.08 % felt Lack of awareness, 66.67% felt Lack of Charging Infrastructure, 49.21% felt EV range issue and 65.08% felt price causes for delay happening in the country in EV adaptation.
   - **Businessmen Self-employed and Healthcare** –
     46.58% felt Lack of awareness, 78.77% felt Lack of Charging Infrastructure, 25.34% felt EV range issue and 63.70% felt price causes for delay happening in the country in EV adaptation.
   - **Government Professionals** -
     31.67% felt Lack of awareness, 38.33% felt Lack of Charging Infras-

tructure, 16.67% felt EV range issue, and 30% felt price causes for delay happening in the country in EV adaptation.

- **Retired Professionals** -
  33.96% felt Lack of awareness, 32.08% felt Lack of Charging Infrastructure, 22.64% felt EV range issue and 24.53% felt price causes for delay happening in the country in EV adaptation.

It is observed that the lack of charging infrastructure is the most significant cause for the delay happening in the country in EV adaptation across professions. Other significant causes include price, lack of awareness and EV range issues. The ambitious target of electrifying 30% of all commercial vehicles in India can be achieved if the issues of lack of charging infrastructure, range anxiety and higher price can be addressed. Most people are unaware of an electric vehicle's operation cost and how it is superior to an ICE vehicle in terms of emissions and operation/maintenance costs. **Lack of awareness about the benefits of EVs are also one of the major issues causing the delay in EV adaptions.**

11 Expectations from Public

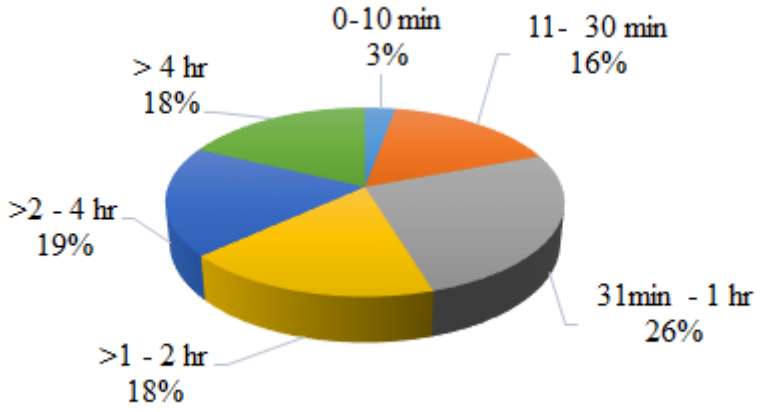
The EV ecosystem has various stakeholders who expect variedly from each other. **The expectations from the user of EVs are, however, the central focus because a satisfied user uses EVs and promotes the usages of EVs.** This section seeks opinions from the respondents to questions related to a few expectations which are specific to the EVs. These include expected charging time, driving range, and the timeframe for EV domination in the mobility sector. In general, most individuals are willing to buy EVs even when charging time is beyond 2 hours. Interestingly, **the expected range shows an increasing trend with age, suggesting that younger individuals prefer EVs to commute shorter distances.** In contrast, older individuals expect EVs to meet the requirements of long-distance travel. Regardless of gender and age, most respondents expect EV to dominate the mobility sector in the next 15 years.

11.1 To consider buying an Electric Vehicle, how quickly (time) would it need to take to fully charge?

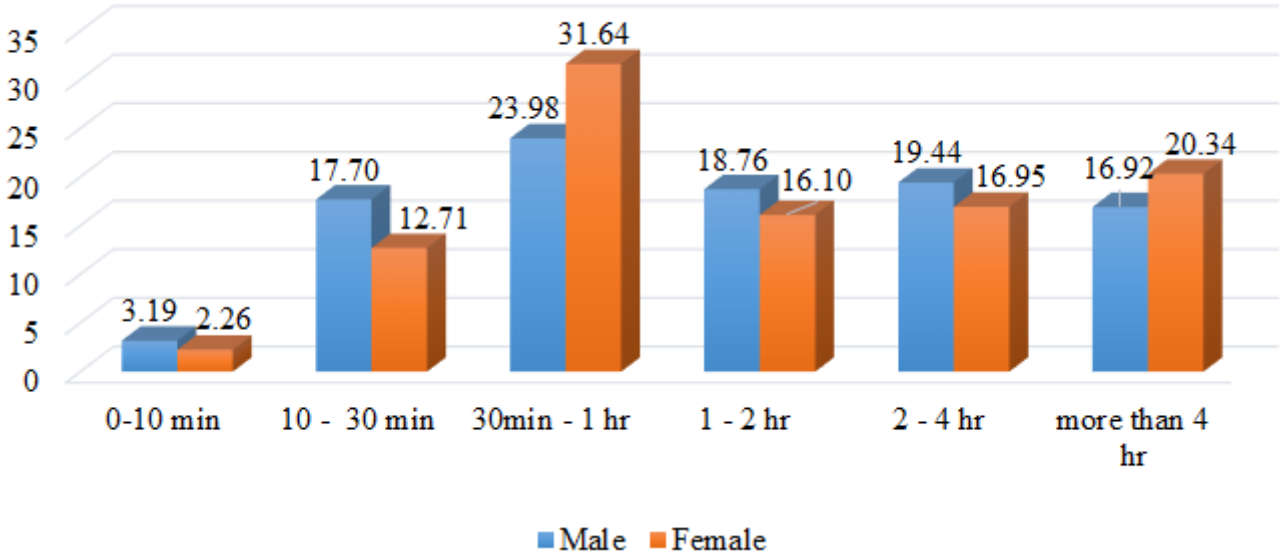
The requirement of **fast charging of batteries in EVs is one of the most common hurdles** for a smoother transition from ICE-based vehicles to EVs. Although the **challenge of range anxiety** is met, there is a possibility of individuals to a tradeoff with the requirements of fast charge; the challenge shall exist. Hence it is essential to get an idea of the expectations of individuals who would consider opting for an EV for transportation.

Another challenge with the requirements of fast charge is its relation with the rate of battery degradation. **With an increase in the charging rate, the rate of battery degradation increases.** Hence, the challenge of fast charge is a problem statement involving the upgradation of existing electric infrastructure to support fast chargers and working on the electrochemistry of the

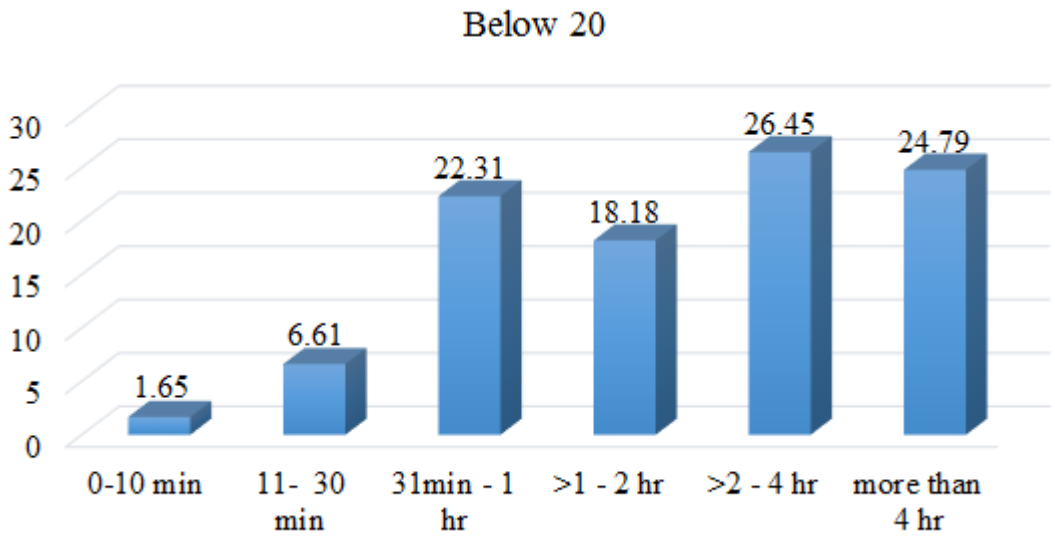
battery to improve the capability to fast charge with constrained battery degradation. **In this survey, charge timing ranging from 0 to more than 2 hours is given for the respondents to discretely analyze the variations of choice with changes in gender, age, educational qualifications, and occupation.**

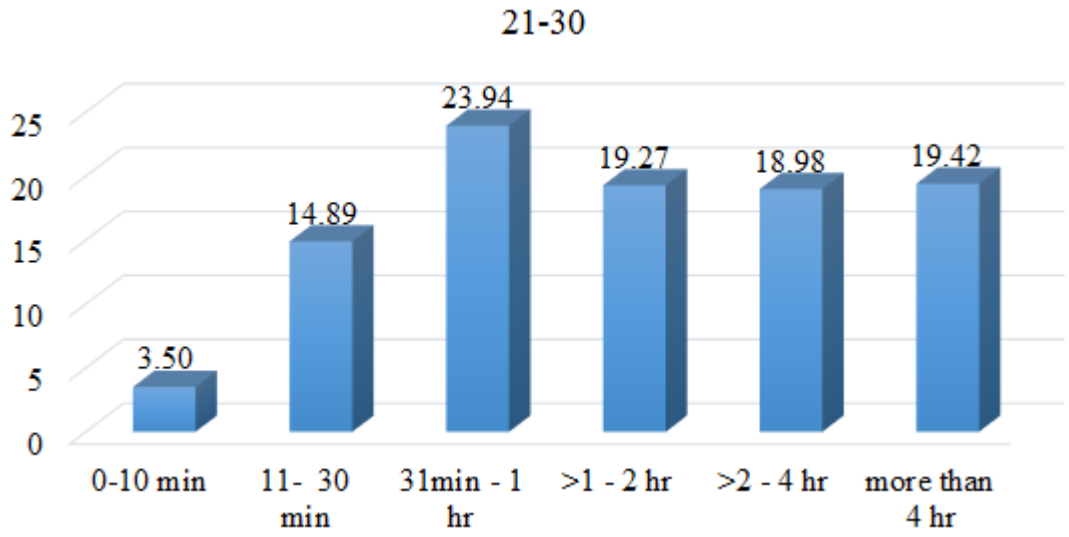


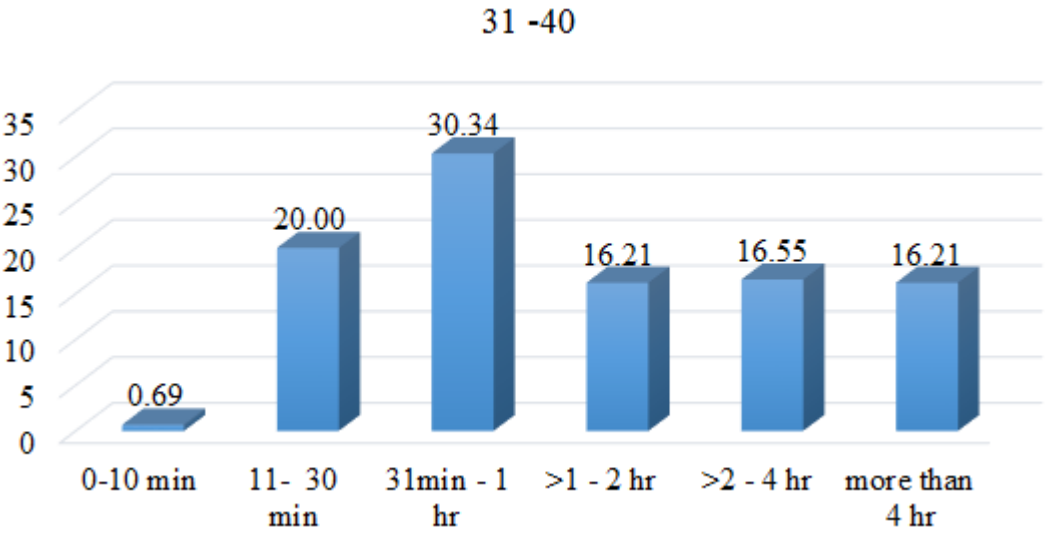
11.1.1 Gender

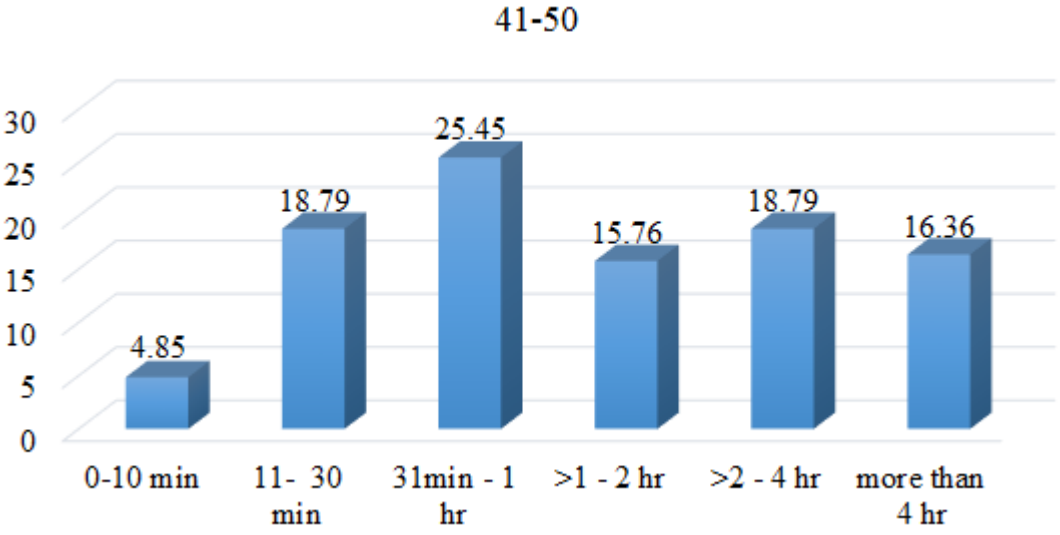


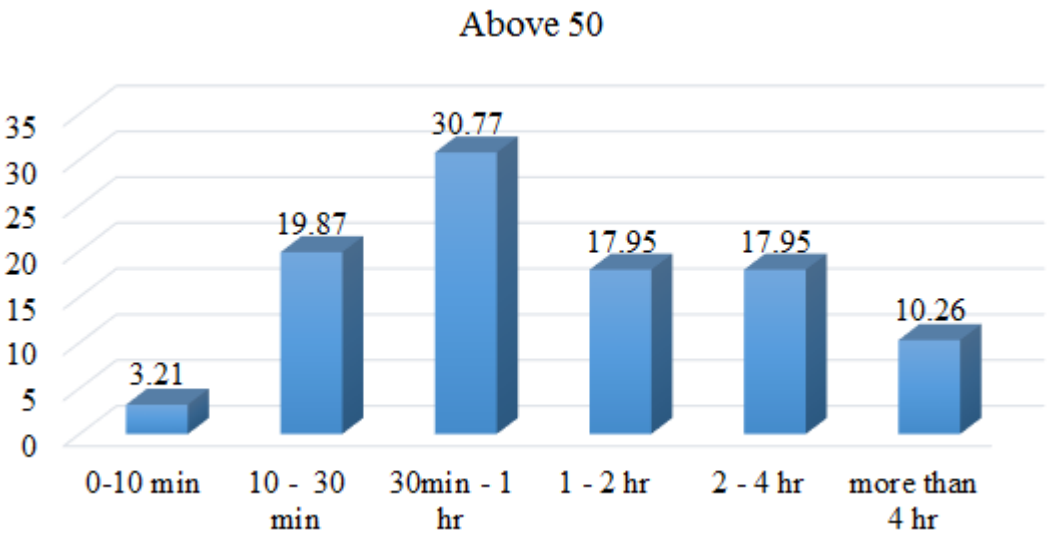
11.1.2 Age



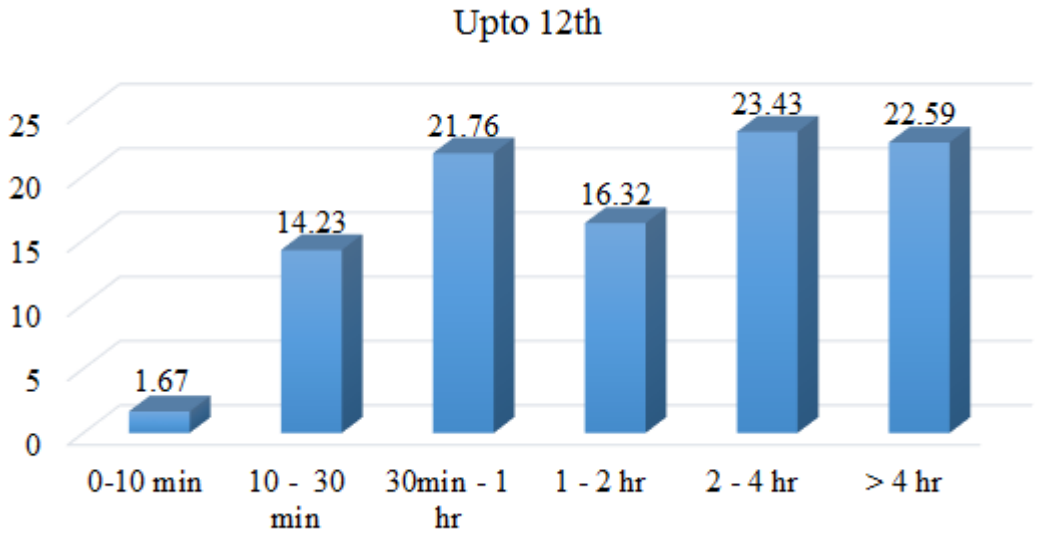

21-30
25
20
15
10
5
0
3.50
14.89
23.94
19.27
18.98
19.42
0-10 min
11- 30 min
31min - 1 hr
>1 - 2 hr
>2 - 4 hr
more than 4 hr

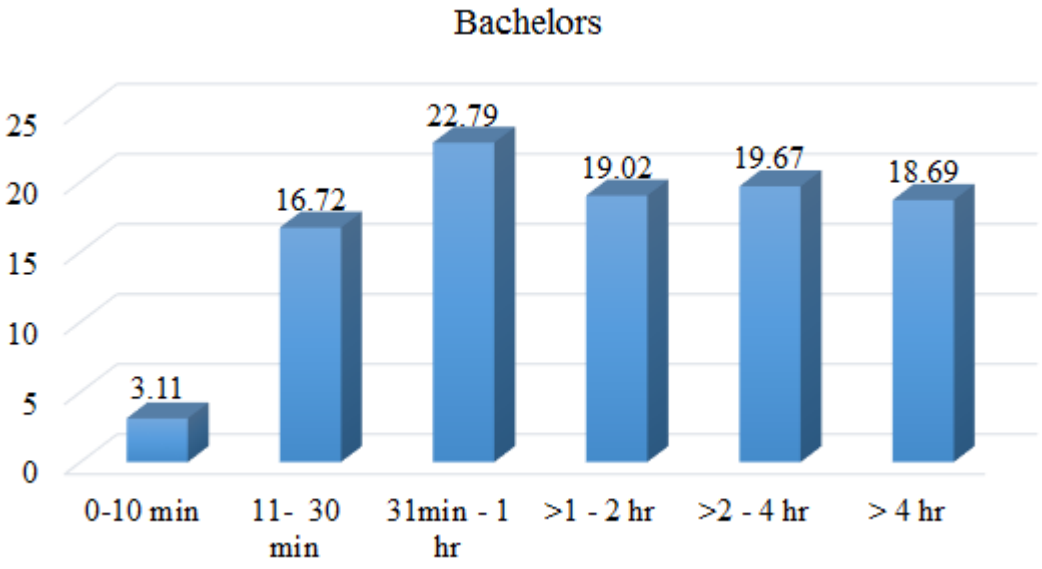

31 -40
35
30
25
20
15
10
5
0
0.69
20.00
30.34
16.21
16.55
16.21
0-10 min
11- 30 min
31min - 1 hr
>1 - 2 hr
>2 - 4 hr
more than 4 hr

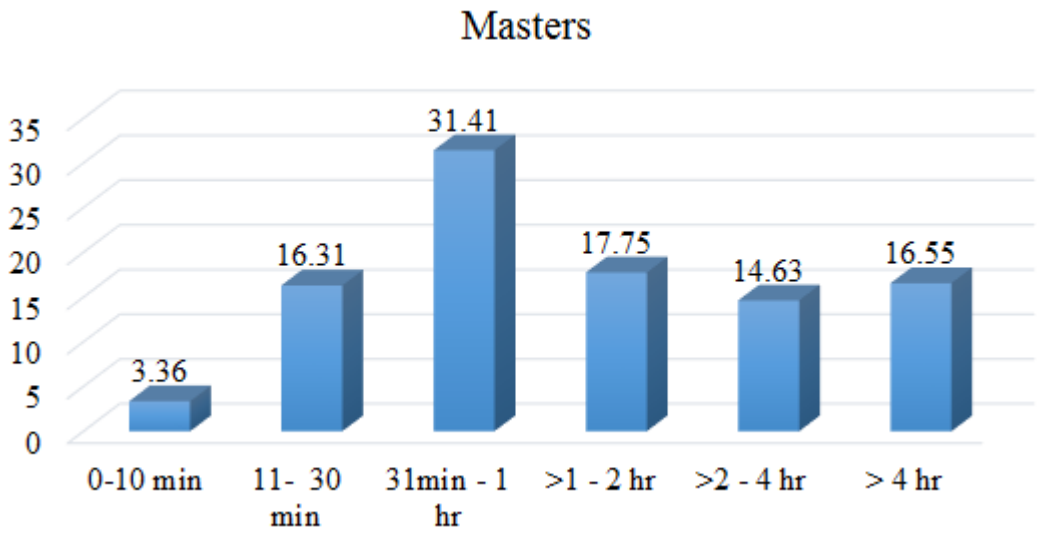

41-50
30
25
20
15
10
5
0
4.85
18.79
25.45
15.76
18.79
16.36
0-10 min
11- 30 min
31min - 1 hr
>1 - 2 hr
>2 - 4 hr
more than 4 hr

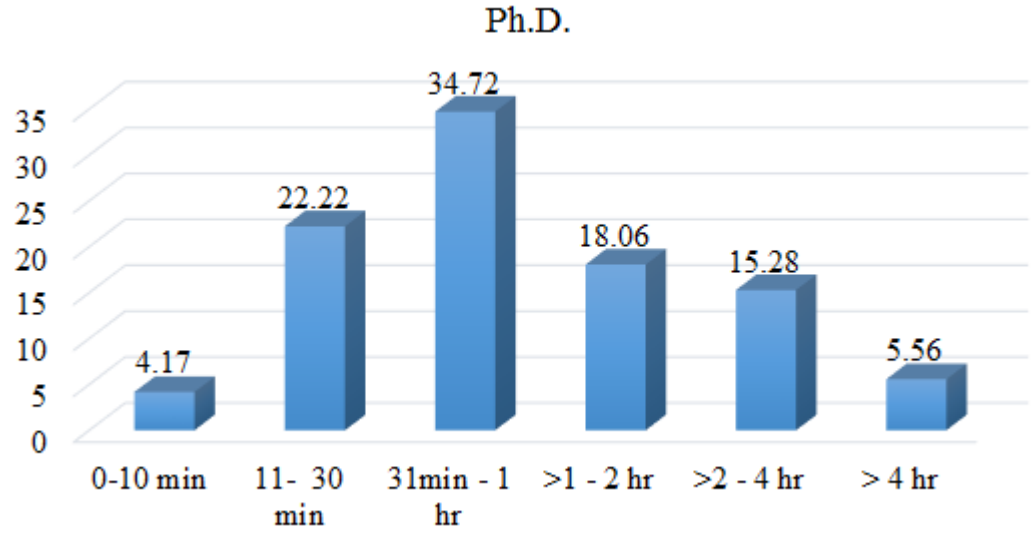


11.1.3 Education Qualification

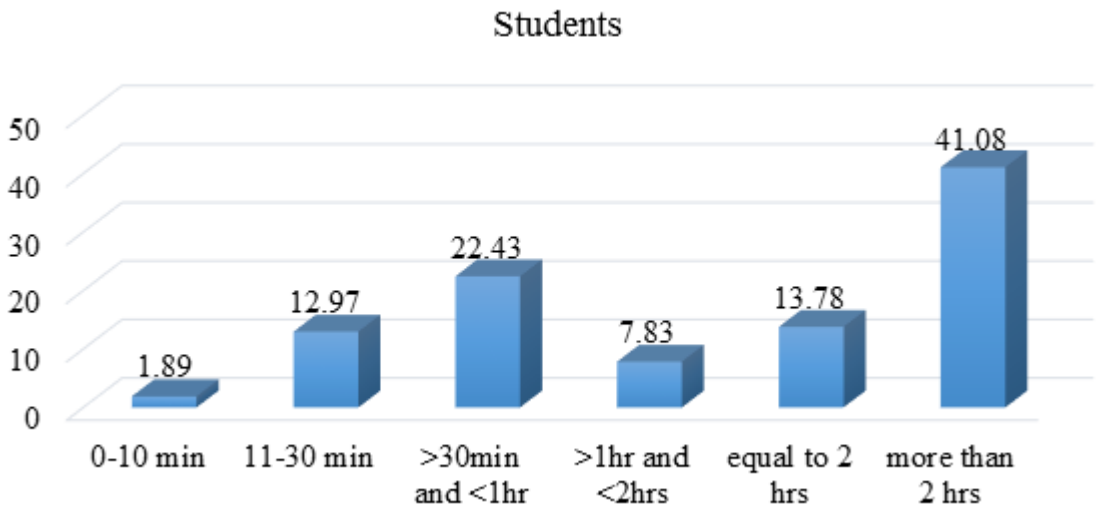


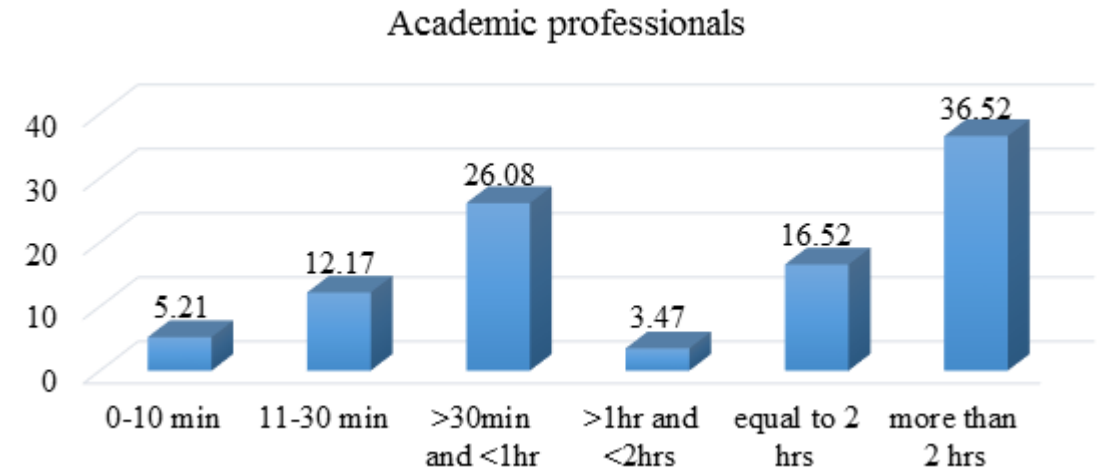


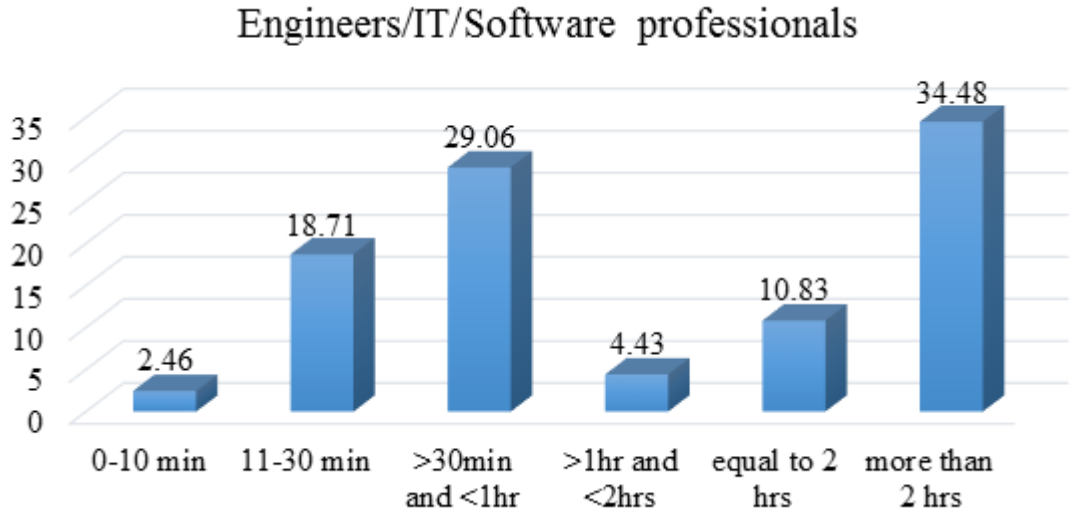


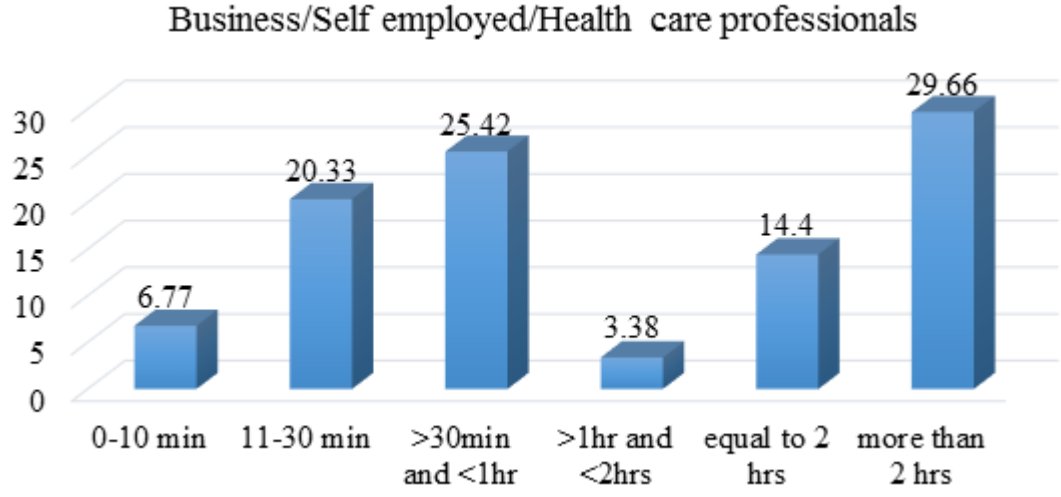


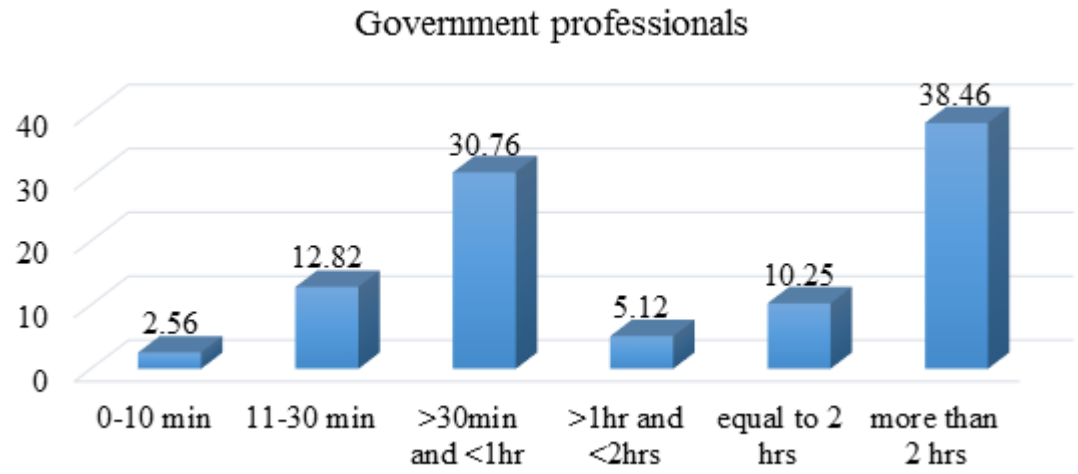
11.1.4 Occupation

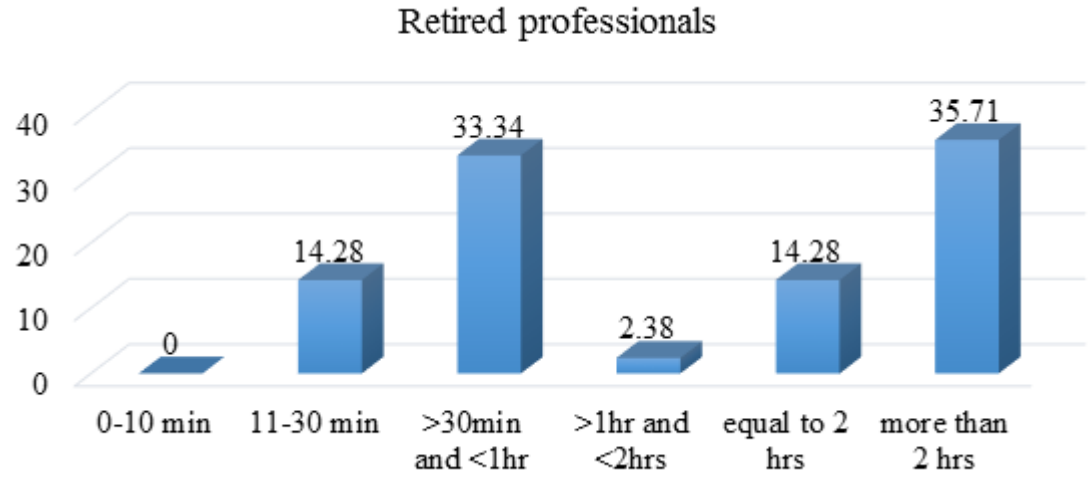


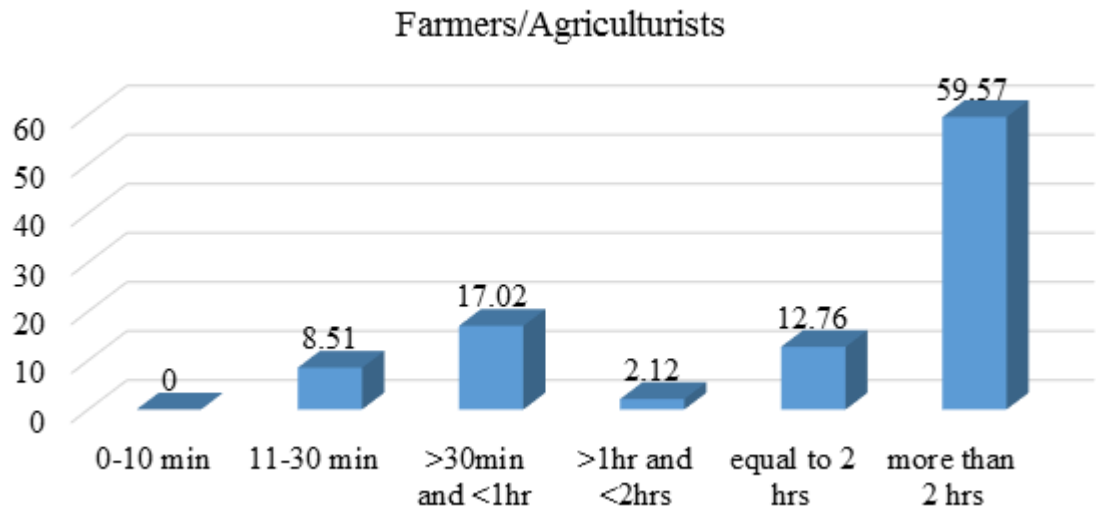

Academic professionals
40
30
20
10
0
5.21
12.17
26.08
3.47
16.52
36.52
0-10 min
11-30 min
>30min and <1hr
>1hr and <2hrs
equal to 2 hrs
more than 2 hrs

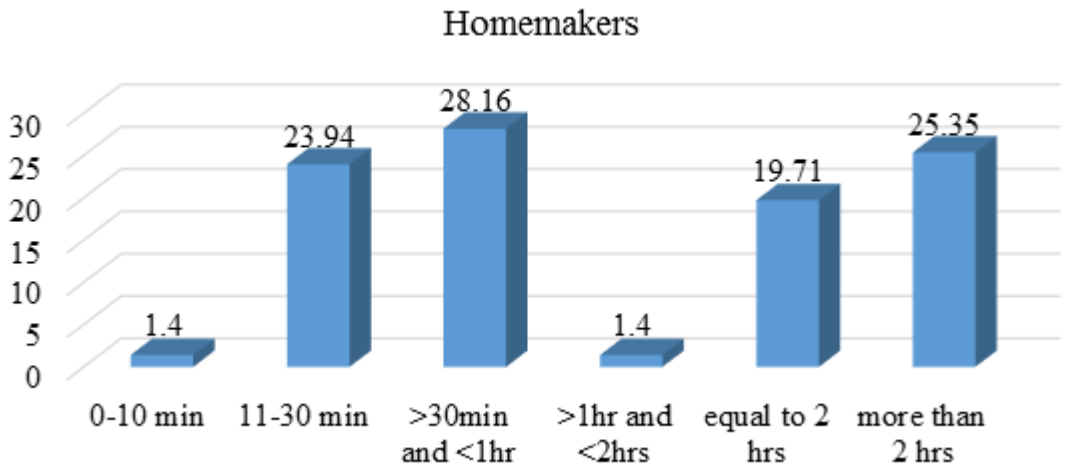

Engineers/IT/Software professionals
35
30
25
20
15
10
5
0
2.46
18.71
29.06
4.43
10.83
34.48
0-10 min
11-30 min
>30min and <1hr
>1hr and <2hrs
equal to 2 hrs
more than 2 hrs


Business/Self employed/Health care professionals
30
25
20
15
10
5
0
6.77
20.33
25.42
3.38
14.4
29.66
0-10 min
11-30 min
>30min and <1hr
>1hr and <2hrs
equal to 2 hrs
more than 2 hrs


Government professionals
40
30
20
10
0
2.56
12.82
30.76
5.12
10.25
38.46
0-10 min
11-30 min
>30min and <1hr
>1hr and <2hrs
equal to 2 hrs
more than 2 hrs

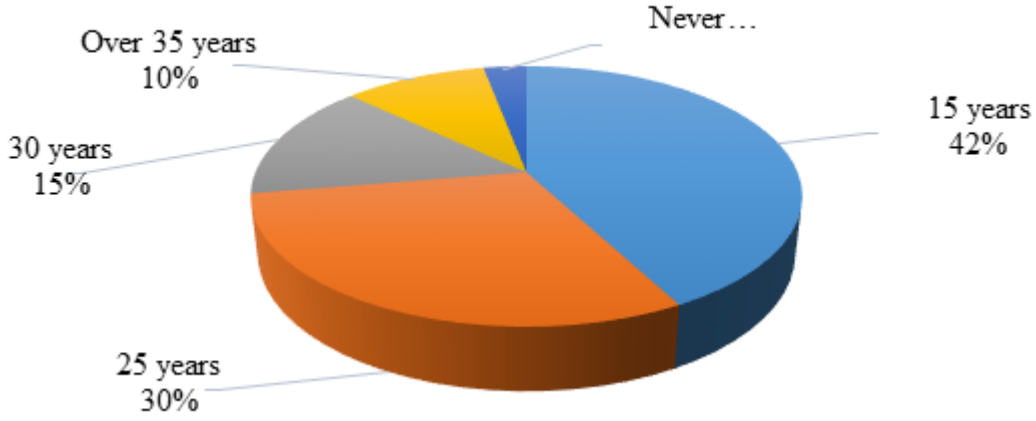

Retired professionals
40
30
20
10
0
0
14.28
33.34
2.38
14.28
35.71
0-10 min
11-30 min
>30min and <1hr
>1hr and <2hrs
equal to 2 hrs
more than 2 hrs


Farmers/Agriculturists
60
50
40
30
20
10
0
0
8.51
17.02
2.12
12.76
59.57
0-10 min
11-30 min
>30min and <1hr
>1hr and <2hrs
equal to 2 hrs
more than 2 hrs

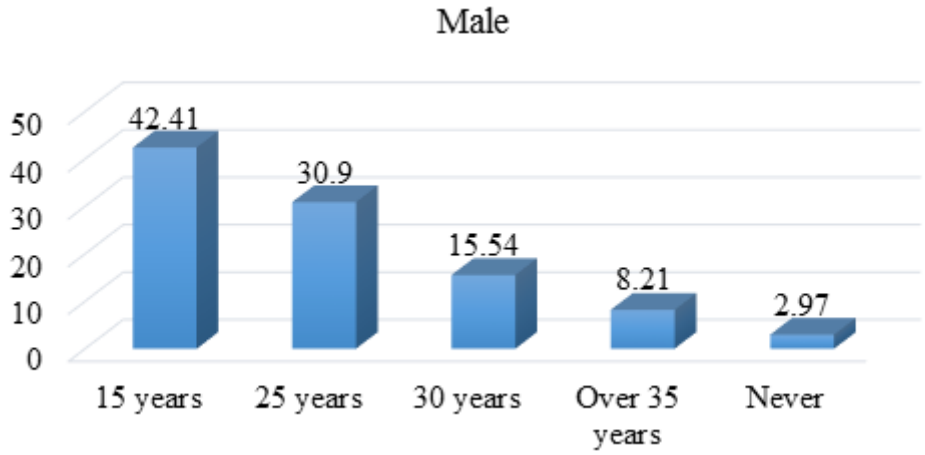


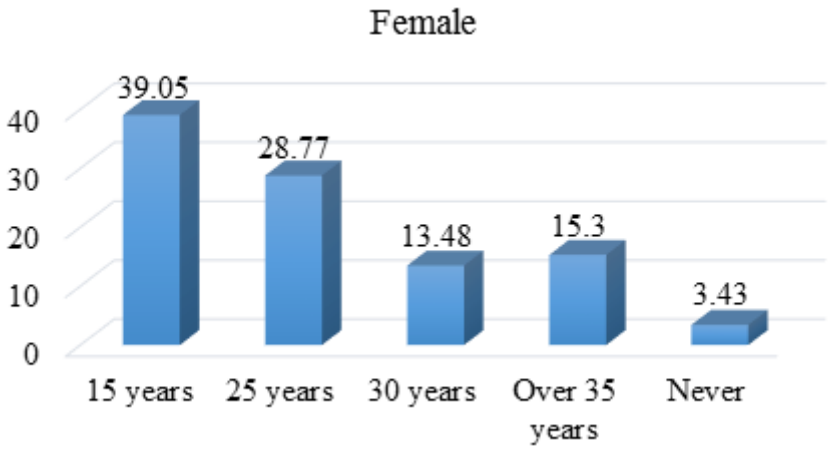
11.2 When do you think Electric Vehicles will comprise the majority of the total Vehicles owned?

The question stated above tries to find out the belief and confidence of an individual on EVs. **An individual who visualizes the dominance of EVs in the transportation sector is more confident over the EV technology.** Further, it is more likely that the individual will purchase an EV sooner in the near future. A varied number of years are mentioned in the survey, including an option of "Never", which would help understand individuals' judgement who do not accept newer and greener technologies.

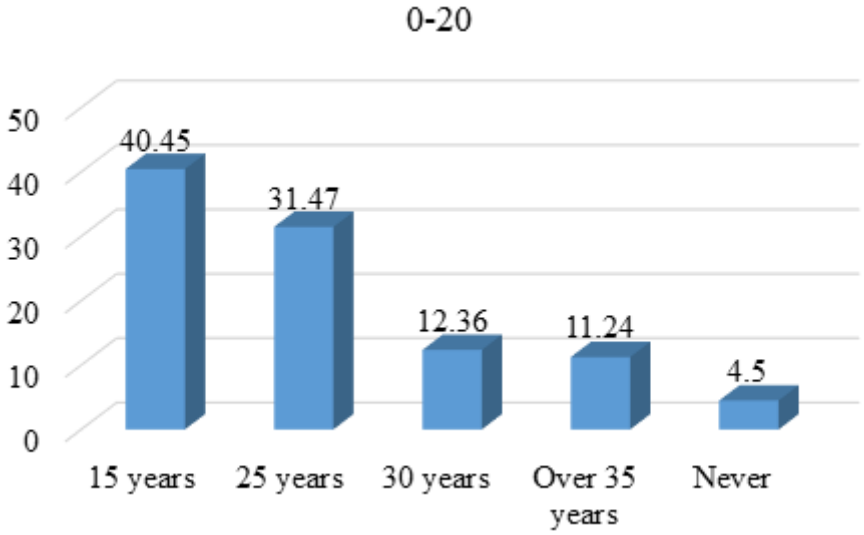


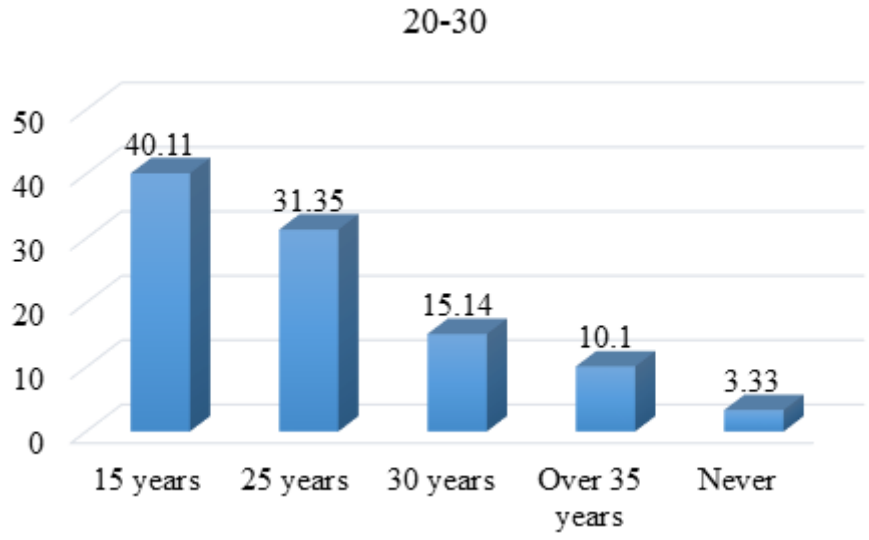
11.2.1 Gender

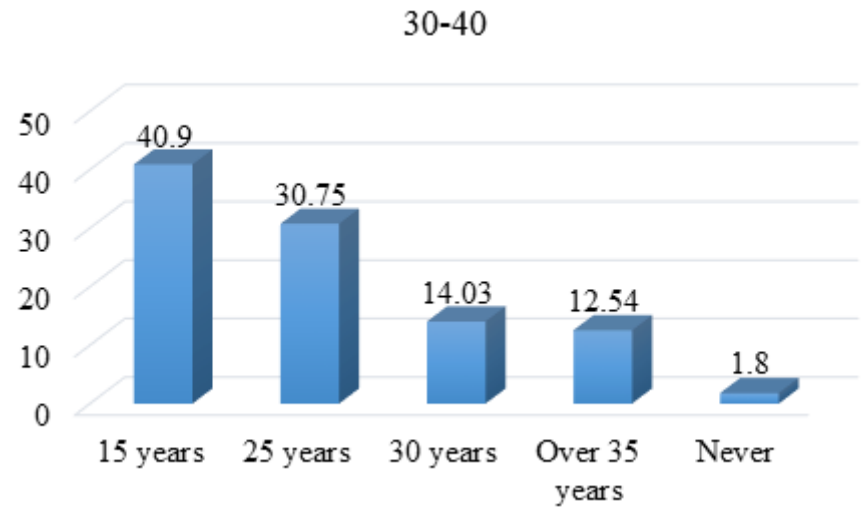


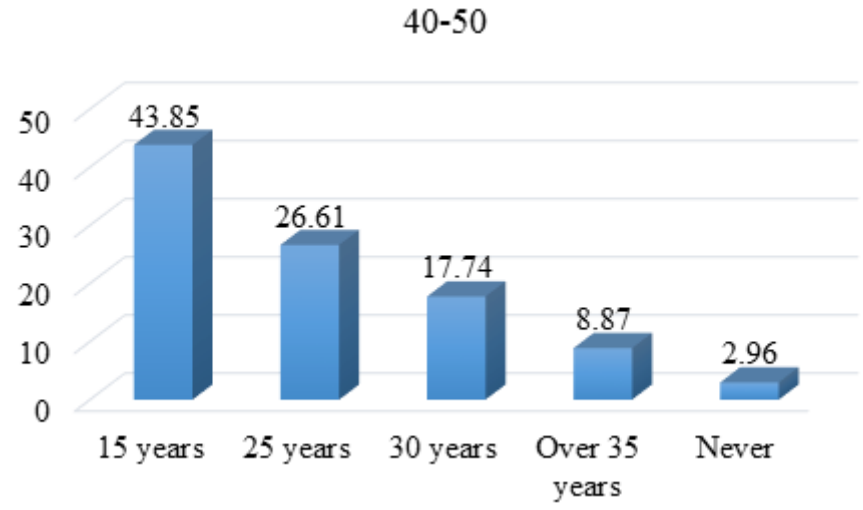


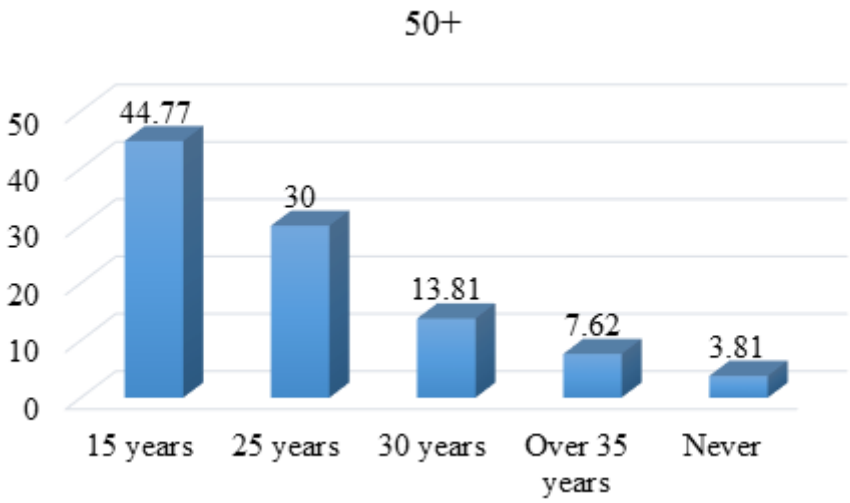
11.2.2 Age



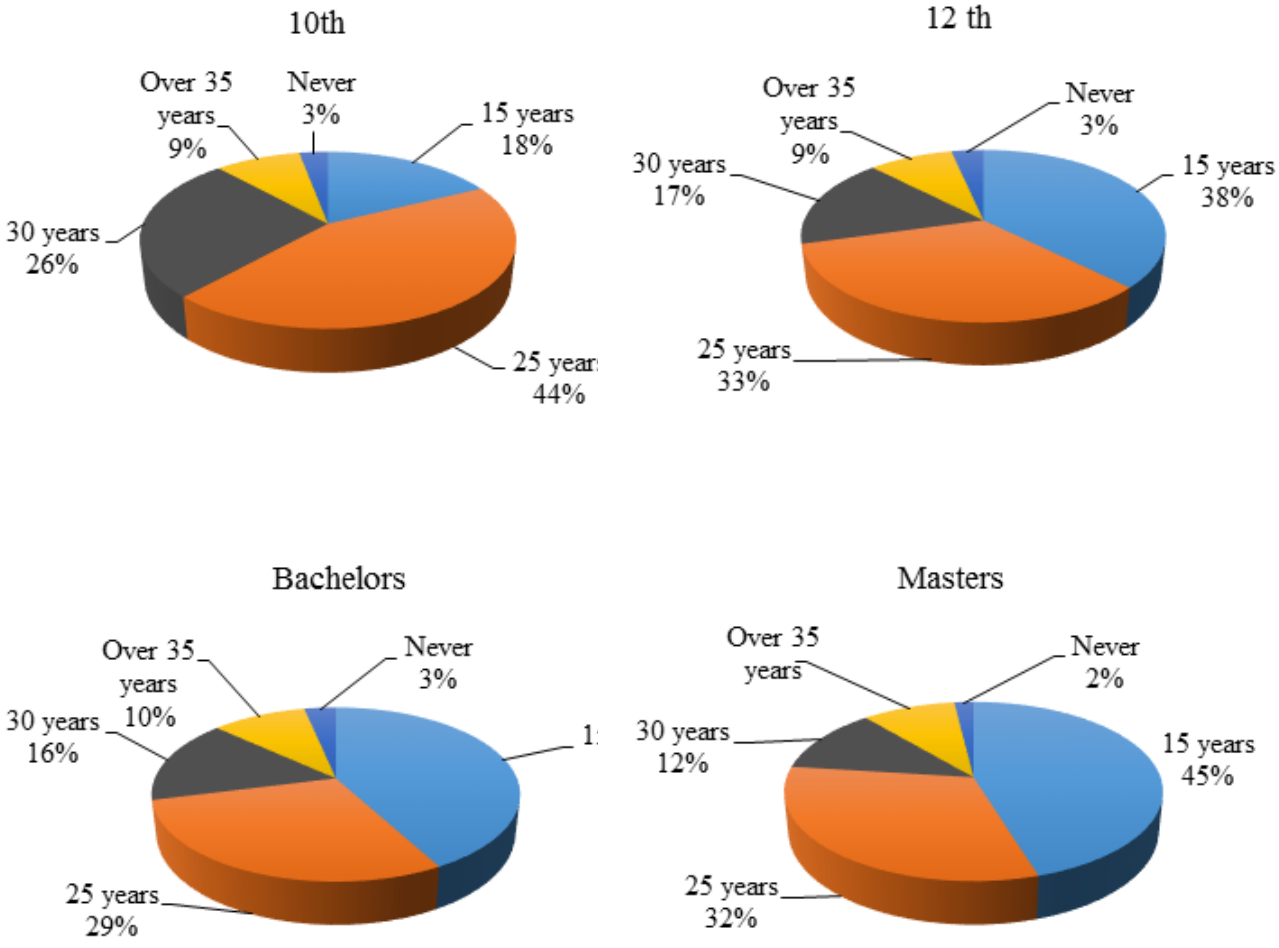

20-30
50
40
30
20
10
0
40.11
31.35
15.14
10.1
3.33
15 years
25 years
30 years
Over 35 years
Never

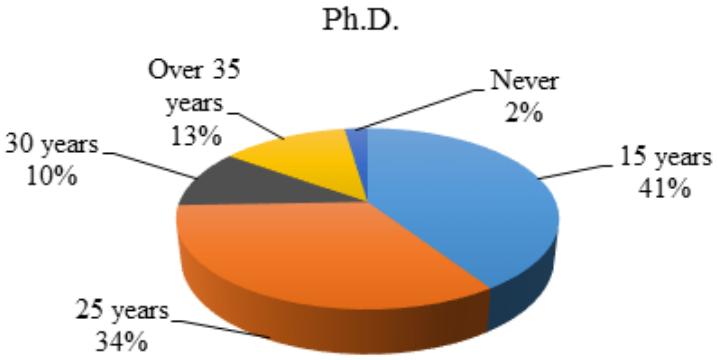

30-40
50
40
30
20
10
0
40.9
30.75
14.03
12.54
1.8
15 years
25 years
30 years
Over 35 years
Never


40-50
50
40
30
20
10
0
43.85
26.61
17.74
8.87
2.96
15 years
25 years
30 years
Over 35 years
Never

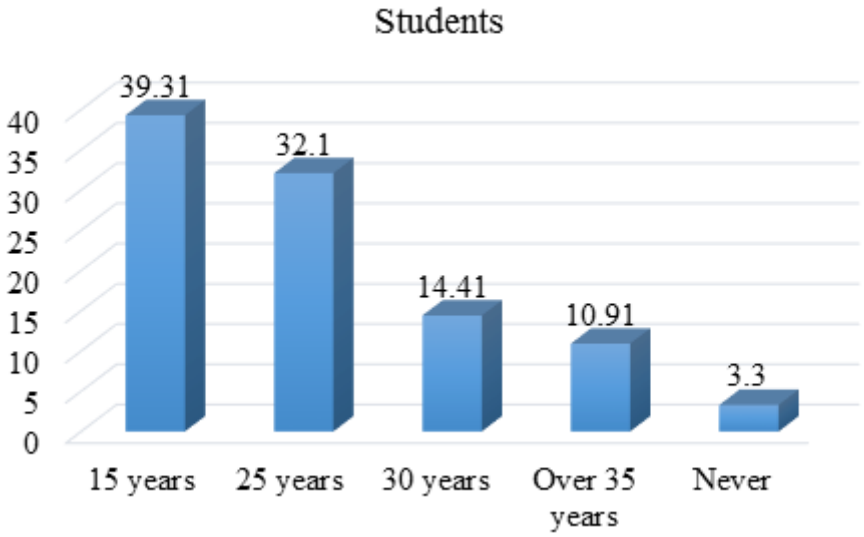


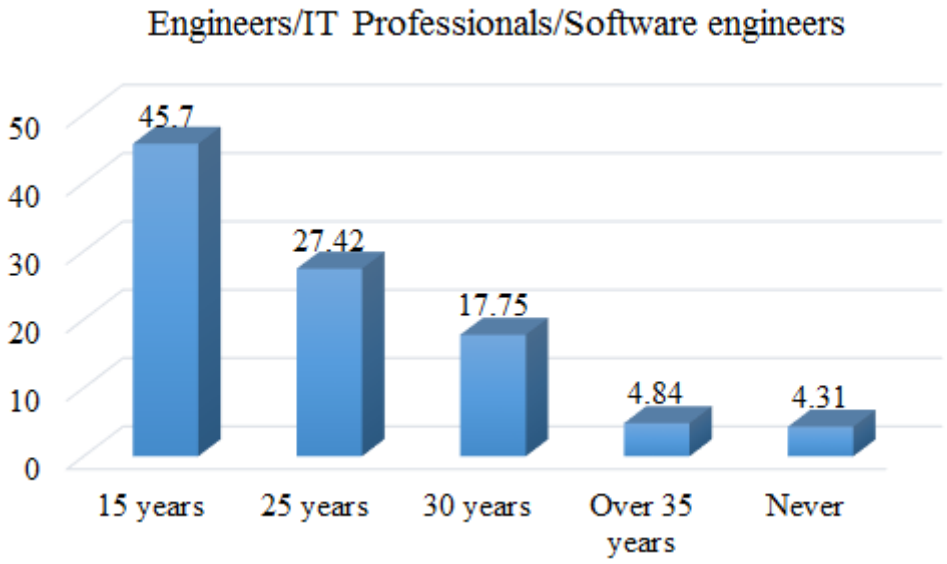
11.2.3 Education Qualification

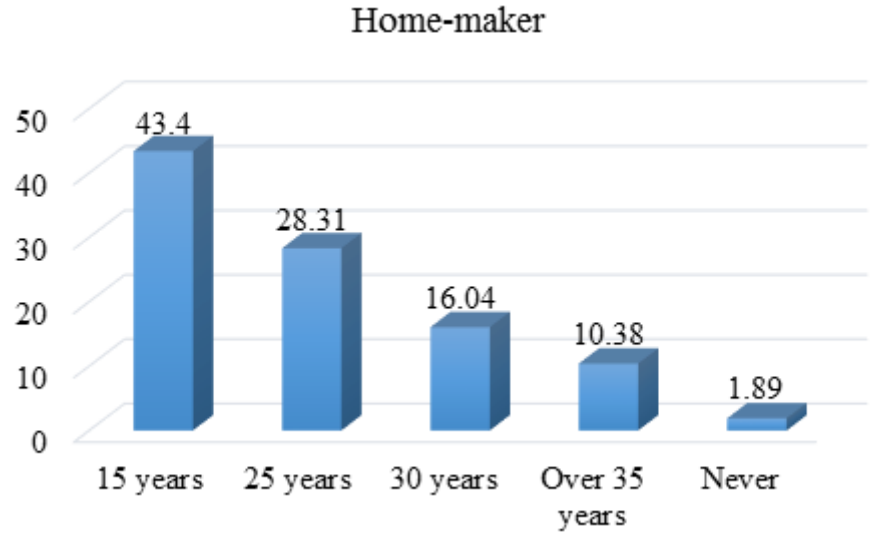


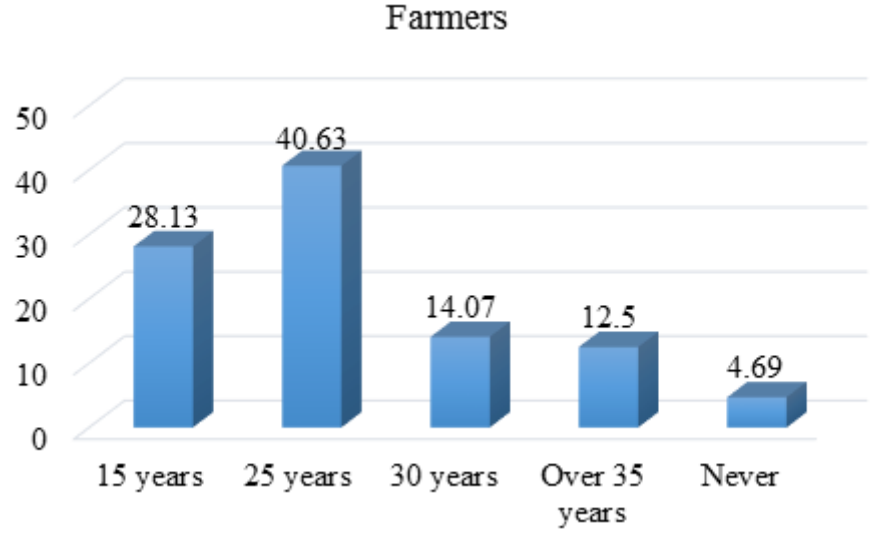


11.2.4 Occupation




Engineers/IT Professionals/Software engineers
50
40
30
20
10
0
45.7
27.42
17.75
4.84
4.31
15 years
25 years
30 years
Over 35 years
Never


Home-maker
50
40
30
20
10
0
43.4
28.31
16.04
10.38
1.89
15 years
25 years
30 years
Over 35 years
Never


Farmers
50
40
30
20
10
0
28.13
40.63
14.07
12.5
4.69
15 years
25 years
30 years
Over 35 years
Never

11.3 Insight and Analysis

1. **Most females (37.04%) and males (38.63%) from the population from the respondents would consider buying an EV even when the charg-**

ing time is beyond 2 hours. 30.56% of females and 20.53% males would consider buying an EV if the charging time is 1 hour. A small fraction of people (2.315 females and 1.77% males) expect charging time under 10 minutes to buy an EV. The respondents of the survey were primarily professionals working in varied organizations with fixed working schedules. Hence, they consider charging EVs while being at home or office in their respective parking areas. However, if the respondents were professionals who use EVs for commercial purposes, it is expected that the percentage of individuals who prefer very fast charging would have been higher.

2. **In general, people irrespective of gender, age, and educational qualification, respondents consider buying an EV even when charging time is more than 2 hours.** The survey results also indicate that charging time of the hour is the most preferred choice by the respondents. A small fraction of people across genders, age groups, and qualifications expect the charging time to be less than 10 minutes.
3. **21.14% of people in the age group between 31 and 40 years and 31.58% with highest educational qualification of** 10^{th} **standard expect charging to be completed between 10 and 30 minutes to consider buying an EV.** It is the highest fraction of people among all age groups and educational qualification for the expected charging time. The lower age groups have a driving rage and relate much with the faster refueling timing similar to ICE-based vehicles.
4. It is observed that, unlike people from various educational backgrounds, there is only slight variation in choices of Ph.D. qualified individuals for the charging times: **10-30 minutes (23.53%), 1 hour (21.57%), 2 hours (19.61%) and greater than 2 hours. (25.49%).** The variations are the least, but the percentage showed a wider range of acceptance to the newer and technologies such as EVs.
5. The respondents' opinions help infer the willingness to buy an EV irrespective of the more considerable charging time; **if a particular occupation is considered, charging time more than 2 hours has the highest percentage** while charging time of 0-10 minutes has the lowest percentage.
6. 0% of farmers and retired professionals believe charging time should be 0-10 minutes, the lowest in the 0-10 minutes category. **59.57% of farmers believe that charging time should be more than 2 hours, which is the highest** in the more than 2 hours category.
7. The majority of **students (41.08%), academic professionals (36.52%), farmers (59.57%), engineers/IT/software professionals (34.48%), business professionals (29.66%) and people who do other occupations (32.55%) preferred to buy an EV irrespective of the charging time which can be more than 2 hours.** In comparison, 28.16% (majority) of homemakers think charging should be more than 30 minutes and less than 1 hour to buy an EV.
8. Considering the responses from people on the required time to full charge based on respondents' age group and comparing their expectations on a range of EVs, interesting insights are observed. Expectations in terms of range and charging time increases with age. **If we take 100 km per hour**

of recharge as base value, 64.53% people have higher expectations than the base value.

9. Most people are quite optimistic about the electric vehicle's occupancy in the market in the near future. **People who do not believe in the transition from ICE-based vehicles to EVs are very small.**
10. Majority of males and females consider 15 years while population belonging from "prefer not to say" category consider **25 years as the time in which electric cars will dominate the vehicles owned.**
11. The insights drawn from the responses shows that the individuals believe in a faster transition from ICE-based vehicles to EVs. As per the survey, **15 years is the expected time for the transition**, which is in line with the target of the Indian government of electrifying the transport sector by 2030.
12. Except for the secondary qualification, which believes that the transition from ICE to EV will be done in 25 years, most people from all other qualification categories considered 15 years as the expected time for a smooth transition. The results obtained are summarised below:
    - **Students**: 15 years (39.31%)
    - **Farmers/ agriculturists**: 25 years (40.63%)
    - **Retired professionals**: 15 years (44%), 25 years (42%)
    - **Homemakers**: 15 years (43.40%)
    - **Engineers and IT professionals**: 15 years (45.70%)
    - **Government professionals**: 25 years (39.71%), 15 years (35.3%)
    - **Academic professionals**: 15 years (42.19%)
    - **Business, self-employed and healthcare professionals**: 15 years (43.13%)
13. **Considering occupation, most people considered 15 years.** Still, farmers, government professionals, and others go out of trend by opting for 25 years as the timeline for the transition from ICE-based vehicles to EVs.

12 Awareness Check

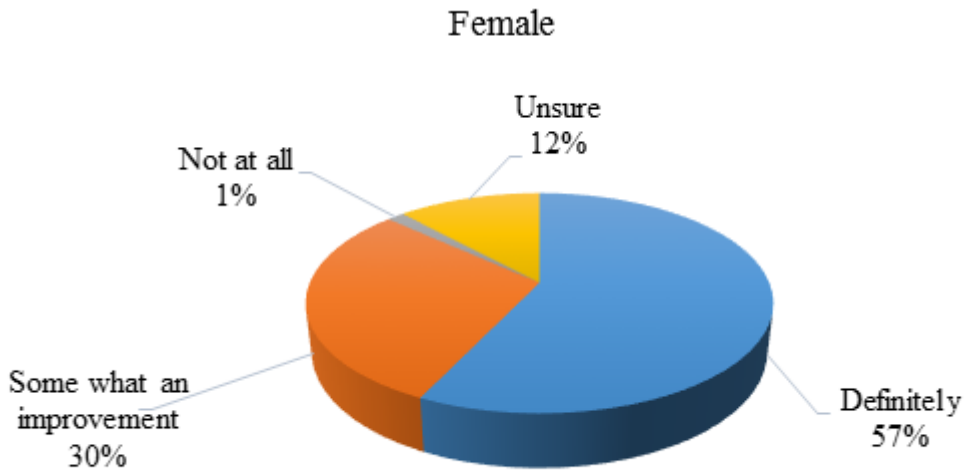
The awareness about the causes for promoting EVs forms the basis of ensuring wider acceptance and smooth transitioning from ICE-based vehicles to EVs. Hence, **an attempt to capture the respondents' awareness is also made by asking questions about environmental aspects and the benefits of opting for EVs.** A similar analysis performed in the previous sections is based on gender, age, educational qualifications, and occupation.

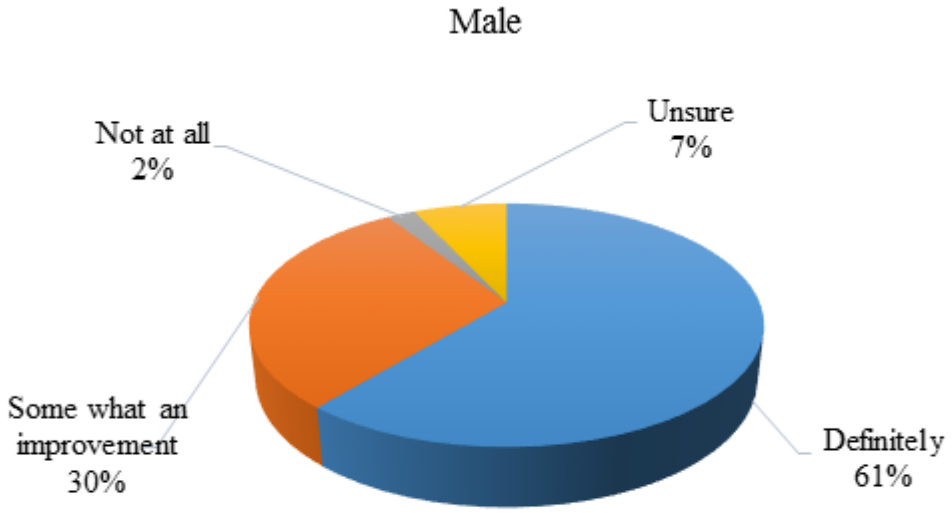
12.1 Do you feel that Electric Vehicle improves the environment?

The primary reason for promoting the usages of EVs is reducing the carbon emissions from ICE-based vehicles to zero. The transportation sector contributes more than 25 % of the total greenhouse gas emissions. The rise in the global temperature, poor air quality, and extinction of fossil fuel reserves have been a few general causes to promote greener technologies by various governments and organizations worldwide. Although the respondents were asked to specify their choice to purchase EVs instead of ICE-based vehicles, it is crucial

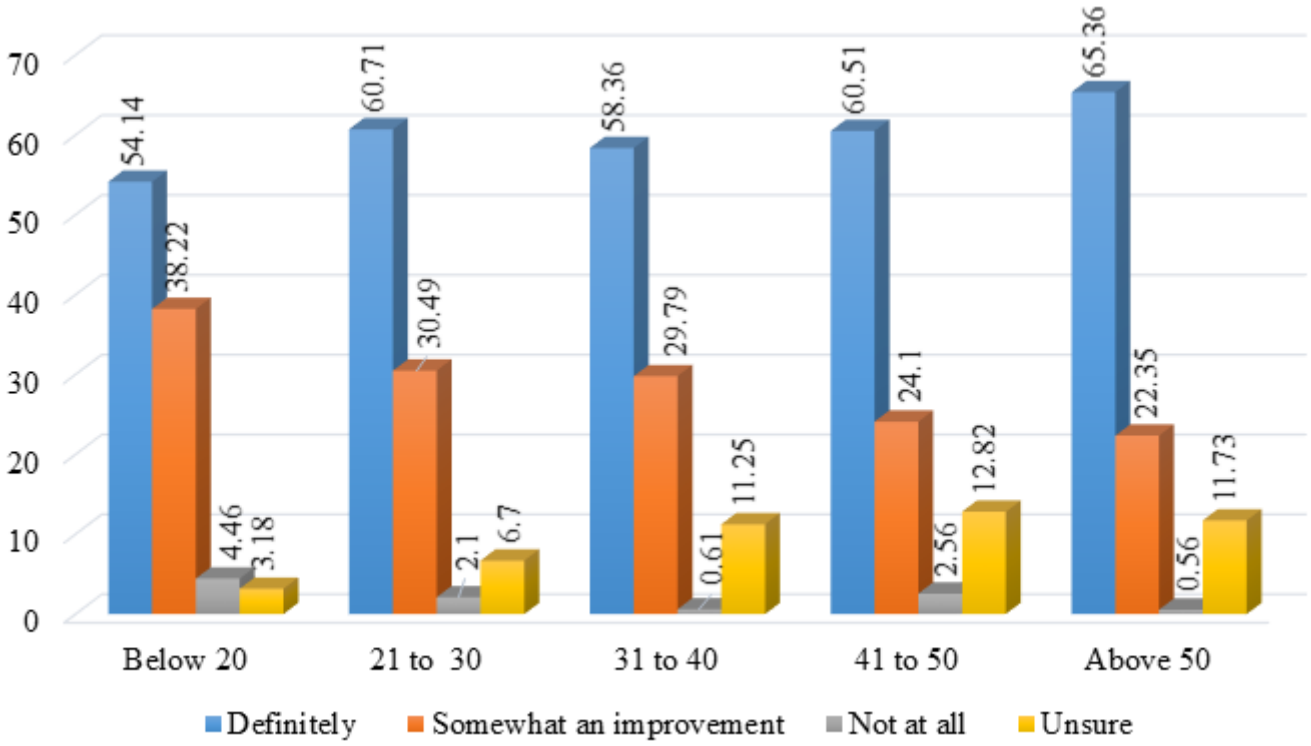
to understand the environmental changes globally. Hence, a similar analysis incorporating awareness based on gender, age, educational qualifications, and occupation is done.

12.1.1 Gender

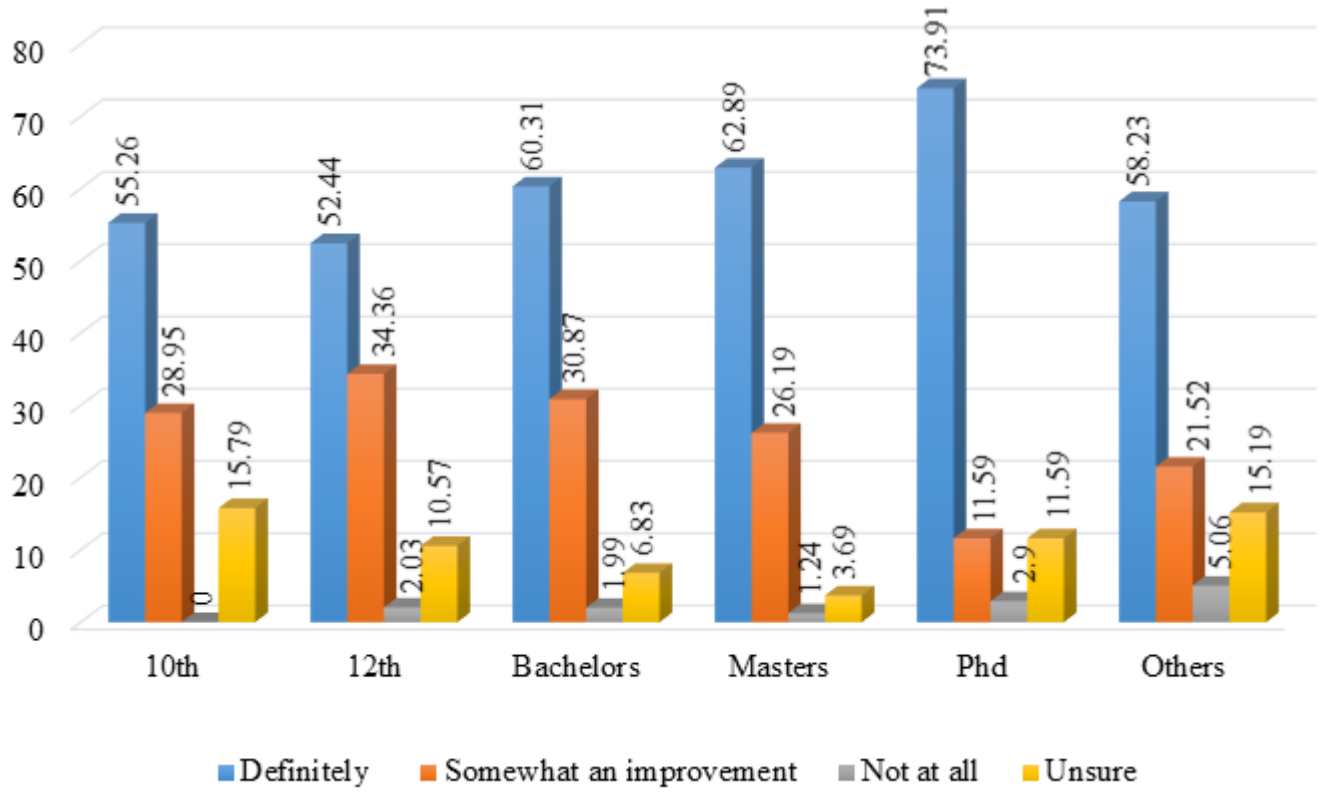




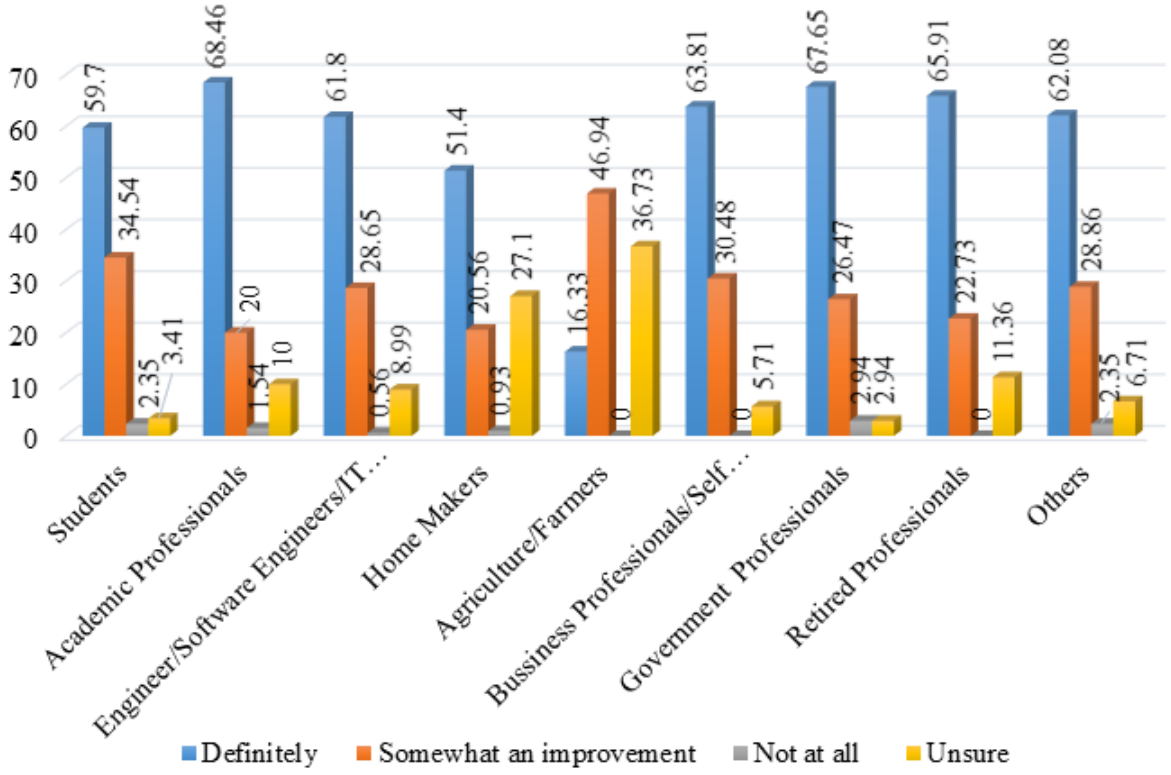
12.1.2 Age



12.1.3 Education Qualification



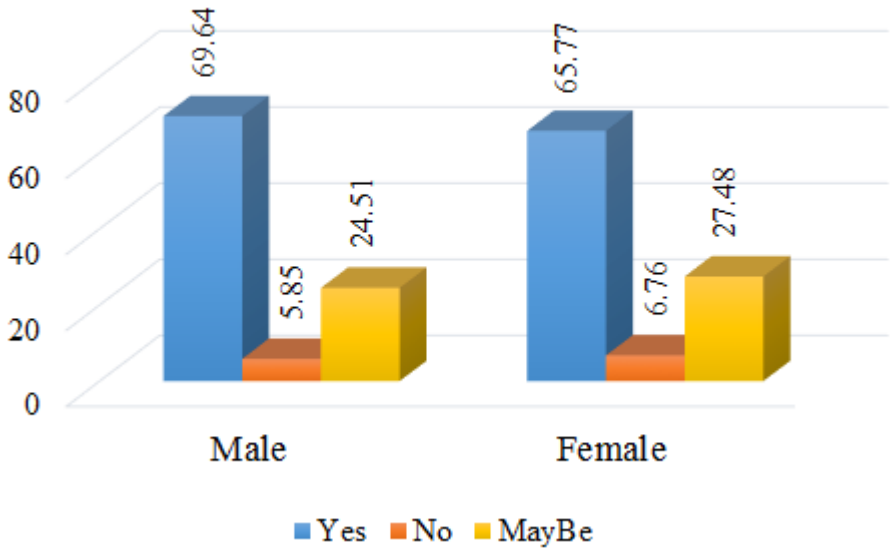
12.1.4 Occupation



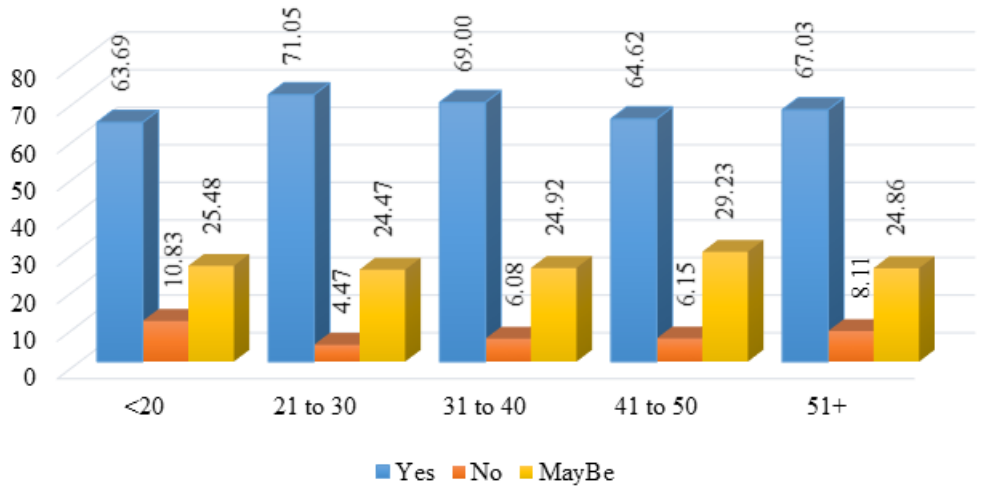
12.2 Do you think owning an Electric Vehicle over ICE Vehicle is an advantage?

The shift by the ICE-based vehicle to EVs can be either because many organisations and governmental initiatives provoked an individual or the individuals are aware of the benefits an EV would have when compared to conventional ICE-based vehicles. **The question aims to find if the respondents are aware of the benefits.** An individual who is aware of the benefits of EV will opt to buy and at the same time promote its usage among the community. Hence, analysis is presented by determining the variation of opinions with changes in gender, age, educational qualifications, and occupation.

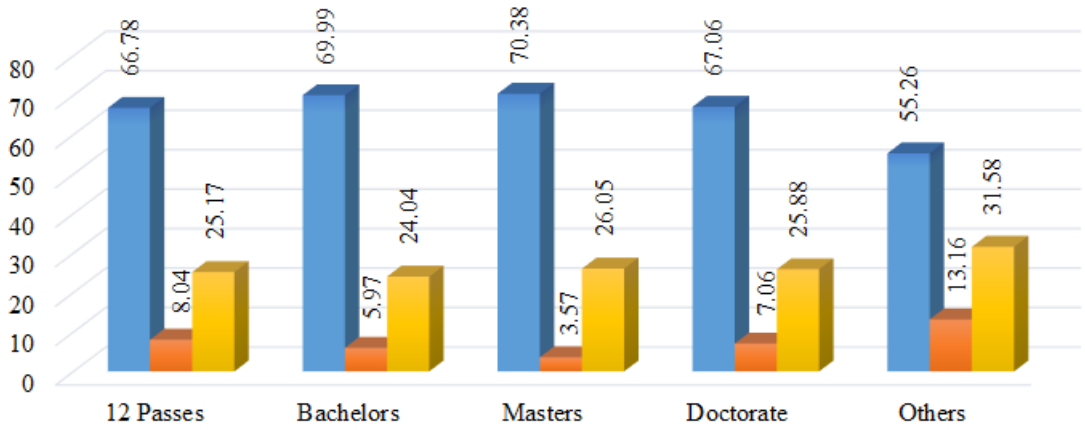
12.2.1 Gender



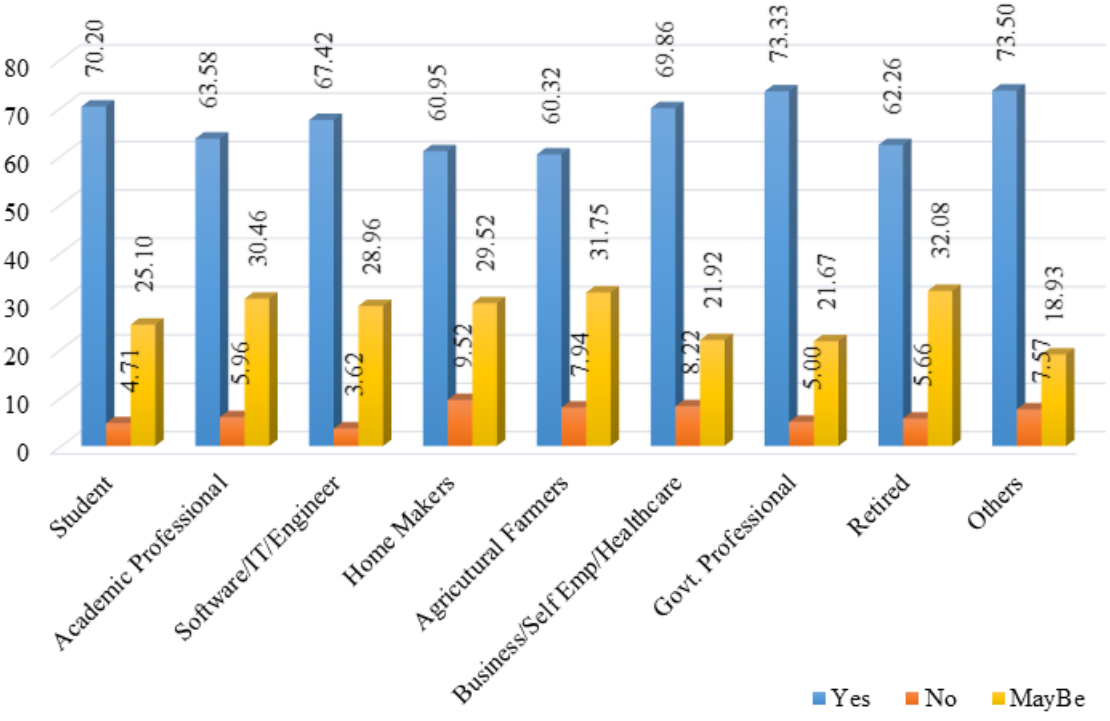
12.2.2 Age



12.2.3 Education Qualification



12.2.4 Occupation



12.3 Insight and Analysis

1. The comparison of the results obtained based on gender shows that majority of the respondents are aware of the benefits of using EVs. **57% female thinks that it will definitely improve the environment, and 30% think somewhat an improvement. Similarly, 61% of males believe it will definitely improve the environment, and 30% believe it is slightly an improvement.** The respondents are primarily elite. Hence, the majority were aware of the benefits. However, the number may vary when respondents are from non-elite unorganized working groups.
2. Based on age, 54% of people from the below 20 age group think it will improve the environment, and 33% believe it will improve. 60%of people in the 21 to 30 age group feel that it will improve the environment, and 30% think it is somewhat an improvement. **58% of people from the 31 to 40 age group believe that it will improve the environment, and 29% believe it is slightly an improvement.** 60% of people from the 41 to 50 age group think it will improve the environment, and 24% believe it is somewhat an improvement. 65% of people from the above 50 age group believe it will improve the environment, and 22% believe it is somewhat an improvement.
3. On the basis of education qualification, it is inferred that 55% of people from secondary education think that it will definitely improve the environment and 29% think somewhat an improvement. 52% of people from higher secondary education think that it will definitely improve the environment and 24% think it is somewhat an improvement. 60% of people with bachelor's degrees believe that it will definitely improve the environment, and 30% think it will improve. 62% of people with master's degrees believe that it will definitely improve the environment and 25% think somewhat an improvement. **73% of people from Ph.D. think that it will definitely improve the environment, and 11% believe it is somewhat an improvement.**
4. On the basis of occupation, 59% of students think that it will definitely improve the environment and 34% think somewhat an improvement. 68% of academic professionals think that it will definitely improve the environment, and 20% think somewhat an improvement. 61% of engineers think that it will definitely improve the environment and 28% think somewhat an improvement. 51% of homemakers think that it will definitely improve the environment and 21% think somewhat an improvement. **16% of farmers think that it will definitely improve the environment and 46% think it somewhat an improvement. 63% of self-employed/business persons thinks that it will definitely improve the environment and 30% think somewhat an improvement.** 67% of government professionals think that it will definitely improve the environment and 26% think somewhat an improvement. 65% of retired professionals think that it will definitely improve the environment and 25% think somewhat an improvement.
5. From the above observations, it can be concluded that irrespective of gender, age, educational qualifications, and occupation, **above 50% of people think that EV definitely improves the environment.** Although EV does help improve the environment, the power generation should also be taken from greener technologies in parallel. If the power generation

remained from a fossil fuel-based system, the belief that EVs improve the environmental condition is just a misconception.

6. The summary of the results obtained are presented below:
   - **Based on age group**
     63.69% of people of the age group of fewer than 20 years, 71.05% of 21 to 30 years, 69.00% of 31 to 40 years, 64.62% of 41 to 50 years and 67.03% of 51 years plus felt owning an EV over ICE is an advantage.
   - **Based on gender**
     69.64% of men and 65.77% of women felt owning an EV over ICE is an advantage.
   - **Based on Education Qualification**
     66.78% of the population with educational qualification less than 12^th pass, 69.99% of bachelors, 70.38% of masters, 67.06% of doctorates, and 55.26% Others qualifications felt owning an EV over ICE is an advantage.
   - **Based on Occupation**
     70.20% of Students, 63.58% of academic professionals, 67.42% of software/IT/ engineers, 60.95% of homemakers, 60.32% of agricultural Farmers, 69.86% of business/self-employed and healthcare, 73.33% of government professionals, 62.26% of retired professionals, and 73.50% of "others" occupation felt owning an EV over ICE is an advantage.

13 Insights

The previous sections have presented insights based on the results specific to a particular question. This section presents insights relating to various aspects of survey questions and the responses received from the respondents.

13.1 Electric Vehicle Ownership

The survey gave interesting insights into the possibility of an individual owning an EV. Apart from the individuals who own a vehicles, those who have never driven and owned any vehicle have also shown willingness to purchase EVs in the future. The desire to own an EV is an indicator of the wider acceptance of newer technologies. However, the willingness extends challenges to the EV manufacturers and policy-making bodies to gain the confidence of the prospective users. T**he expectations of an EV user are not just limited to lower cost, more extensive range, fast charging, and required infrastructure; the expectations extend to the safety and reliability while driving a vehicle as well.**

The safety directs towards the batteries in the EVs that are susceptible to exothermic reactions leading to fire, burst, and harmful fumes. These exothermic reactions are a result of operations of batteries outside safety limits. These include operation in over-current mode during charging or discharging, changes in the ambient temperature (at an extremely lower or higher numbers), improper selection of battery electrochemistry and design of battery pack, higher mechanical disturbances while the operation of the battery, lack

of precise BMS to estimate appropriate parameters and ensure appropriate protections, and unforeseeable events such as accidents. Although the survey does not look deeper into the aspects mentioned, the insights pointed out the challenges that the manufacturers of EVs and their related subsystems should not neglect.

13.1.1 A timeline of 5 years

The survey showed that more than 50 % of the respondents are willing to buy EVs as their first vehicle. The number is not suitable to be related to the overall population of the country. However, considering the respondents' educational qualifications and occupation, it can be inferred that most of the people from the organized sector would prefer EVs over ICE-based vehicles. **Further, the individuals working in the unorganized niche of transportation sectors such as rikshaws, cab, and bus drivers are already seen transitioning from ICE-based vehicles to EVs.** The recent purchases of buses in various state run transport corporations such as Ahmedabad Municipal Transport Service, Himachal Road Transport Corporation, and Bihar State Road Transport Corporation are EVs. Similarly, the three-wheelers (mostly called toto or e-rikshaw) have become very popular for drivers providing short-distance commuters.

The pace of transition to EVs in the transport sector is pushed by various policies framed at national and state levels. An example of a current national policy is Faster Adoption and Manufacturing of Electric Vehicles in India Phase II (FAME India Phase II), which is expected to boost manufacturing by original equipment manufacturers and the sale of EVs. **The infrastructure requirement is, however, a challenge at both state and national levels.** Other challenges are common standards to be followed during EV manufacturing systems and by the service providers to EVs, such as charging stations, battery swapping, and cloud support.

13.1.2 A timeline of 10 years

The timeline of 5 years is further extended to 10 years. Considering the numbers corresponding to the respondents who have never owned an EV to date, based on gender, the survey found out that 78% of men and 77% of women have never owned an EV. However, when the interest is analyzed, if the same trend (preference of purchasing an EV by more than 50 % of the respondents) goes on then, within ten years, the survey results shows that the respondents of age between 20 to 40 years would be leading the usage of EVs. **Hence, by the timeline of 10 years, more than 70 % of the respondents would purchase an EV.**

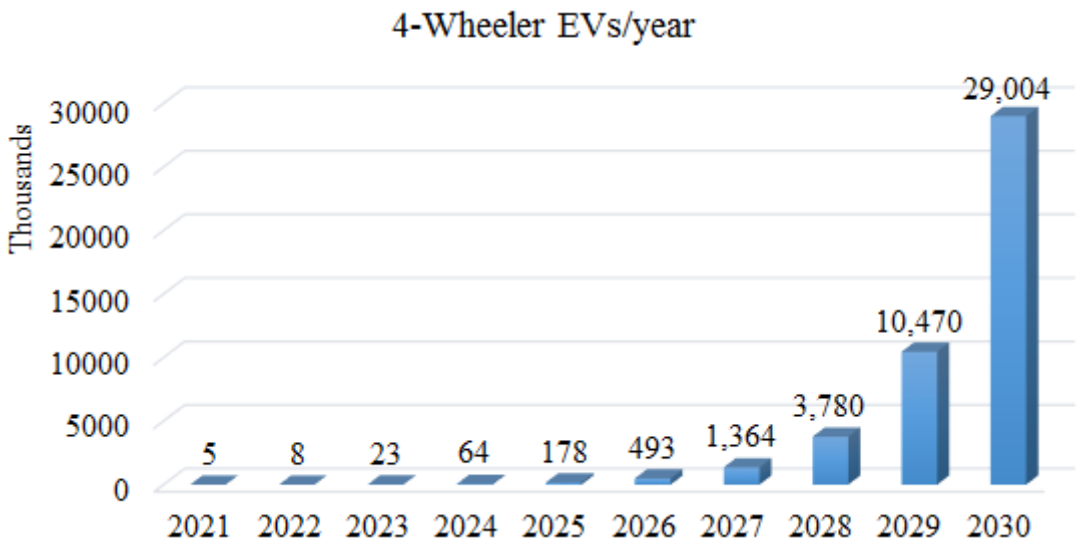
Among all the age groups, every age group has less than 10% of respondents who owned an EV. Though statistically, it is a tiny percentage, across every age group, every occupation and either men or women in the range of 60% to 70% have shown a massive interest in owning this emerging technology in future. **If the challenges mentioned in the previous subsection are met, as per survey results, a smooth and faster transition from ICE-based vehicles to EVs would be visible in the timeline of 10 years.**

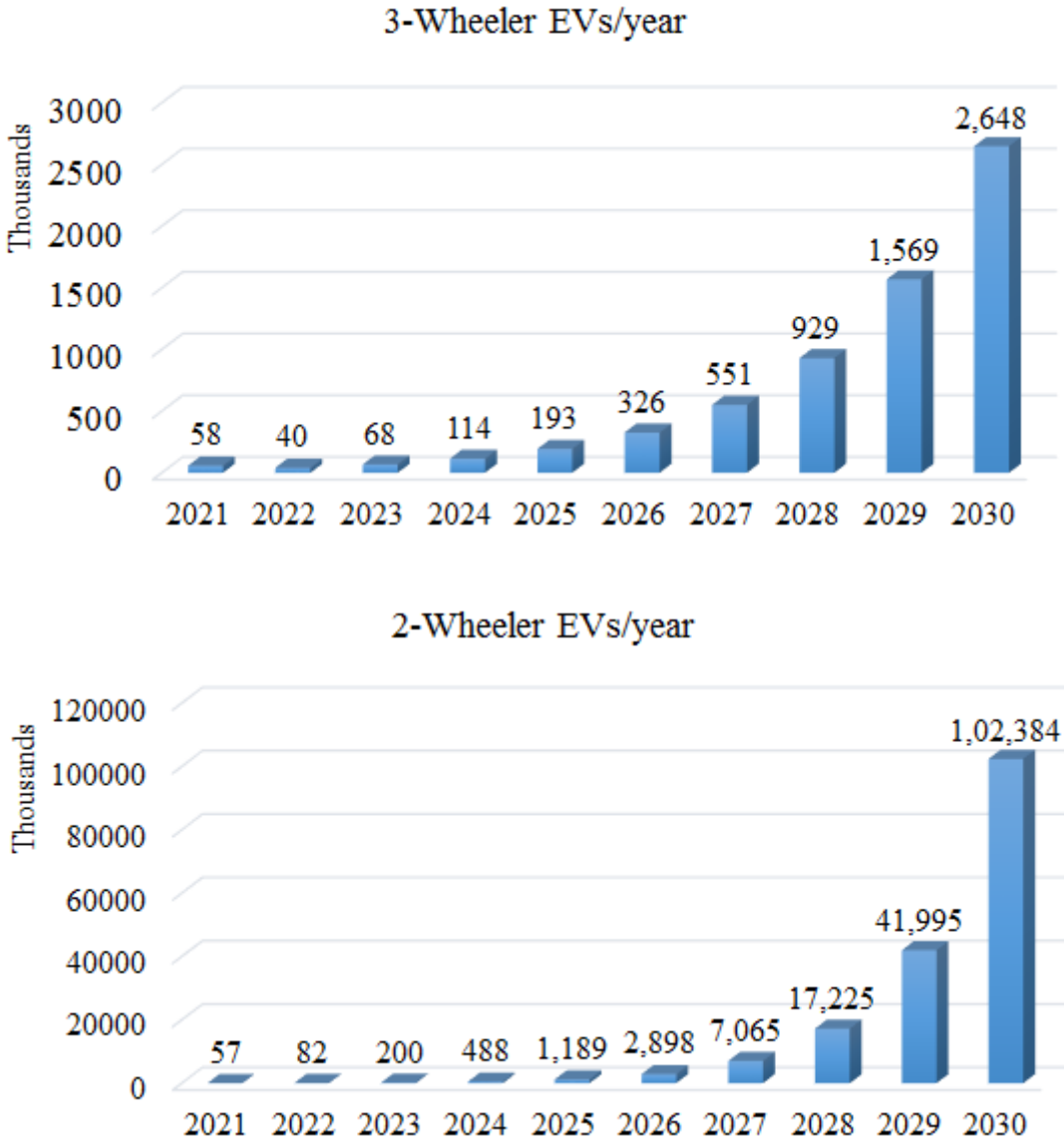
13.2 Average time to adopt to Technology

The time to adopt a technology depends on the confidence of a prospective automobile customer. The belief is to be built by stakeholders in the EV ecosystem. The government organization in India should ensure supportive policies to provoke automobile customers is looking for alternatives to ICE-based vehicles. A few of the policies to support EV sales are higher subsidies while purchases, tax exemptions, and a reliable power supply in every region for easy access to charging. The central and state governments have already implemented these policies but, the implementation challenge is yet to be solved. **The cumbersome processes to get benefits of the subsidies and tax exemption demotivates the choice of EVs.**

By 2030, the Government of India has set targets to replace 30% of IC Engine Vehicles with Electric Vehicles. As per the data, November 2021 available on Vahan website by MoRTH, Govt. of India, 5.29 Crores of 4 wheelers, 0.76 crores of 3 wheelers and 20.23 crores of 2 wheelers are registered in the country. **On an average annual expected growth of 8% sales in each segment, by 2030, 15.12 crores of 4 wheelers, 2.16 crores of 3 wheelers, and 57.80 crores of 2 wheelers will be registered in the country.**

To reach the ambitious targets of replacing 30% of IC Engine vehicles with Electric vehicles, around 4.53 crores of 4 wheelers, 0.65 crores of 3 wheelers, and 17.35 crores of 2 wheelers of Electric vehicles should penetrate the market by 2030. **To reach these massive numbers, EV sales have to be increased by 177%, 68.8%, and 143.8% in 4 wheelers, 3-wheelers, and 2-wheelers segments, respectively.** The plots below show the year-wise manufacturing requirements of Electric vehicles in 4 wheelers, 3-wheelers, and 2-wheelers segments.





The manufacturing and the service providers do not have a set of standards for every system and subsystem of an EV. The standards set by another part of the world does not necessarily meet all the requirements in the Indian scenario. For example, in India, ambient temperature variation is from -15^oC to 45^oC. Such huge variations result in a challenge in the reliability of the overall system. An example of the challenge in reliability is the changes in the rate of degradation with variation in the ambient temperature. Further, the reliability of the discrete components in the power electronics converters and the motor of the powertrain is also impacted. Performance of other components such as motor and auxiliary power supplies are also impacted. As per survey results, **the time to adopt EVs is approximately 15 years by about 42% of respondents, while the other 30% of the respondents consider 25 years or more.**

13.3 Price at which people want to buy the EV

A general expectation of every prospective automobile customer would be to buy an EV at the lowest price with maximum functionalities. However, the OEMs have their own challenges in reducing the cost. **Although government subsidies can provide backing to the expectations of the automobile customer, an assurance of Indian manufacturing base for various**

systems and subsystems of EVs from discrete components to assembly plants would ensure a drastic price reduction.

As per the survey, in every age group or profession, about 30% to 40% of people expect the cost of EV should not be more than ICE-based vehicles. Also, about the same percentage of people in the range of 35% across all professions are willing to buy an EV with 10% more than ICE-based vehicles. However, a good percentage of respondents, 8% to 25% are willing to pay a 20% higher price for EV. Further, a tiny percentage of respondents (less than 10%) are willing to pay 30% more for EV than ICE-based vehicles generously. Table below shows the summary of the expected price of the variants of the EVs.

Type of EV	Expected Price Range (INR)
E-Scooter	85,000 - 90,000
E-Bike	90,000 - 1,10,000
Entry level E-Car	5,00,000 - 6,50,000
Mid level E-Car	9,00,000-10,00,000

As expected by the respondents, the cost of an EV varies over a wider range with a benchmark of the current price of ICE-based vehicles. The popularity of the technology can impact the cost an EV user would bear at the time of purchase. The popularity again depends on the reliability of the technology, available charging infrastructure, and related support service providers. If these three concerns are addressed, a prospective automobile customer might tradeoff with the cost of ICE-based vehicles.

13.4 Environment and Electric Vehicle

The relation between constraining the deteriorating environment and air quality is already discussed in the previous subsections. The lack of understanding on the requirement of greener technologies for power generation must be disseminated among the masses. **However, switching power generation to greener technologies is primarily a concern for the organizations managing the nation's power system.** Hence, the survey results show that 2/3rd of respondents across all the professions believe that EVs can help better the environment.

13.5 Causes for delay in adopting Electric Vehicle

The various challenges related to the faster adaption of EVs are well defined in multiple reports and scientific literature worldwide. However, it is seen that EVs are penetrating in the transportation sector gradually. **The pace of penetration is dependant on one of the critical factors- ease to refuel.** Irrespective of challenges of fuel efficiency, lack of OEMs, lack of servicing stations, and reliability issues, ICE based engine became a preferred choice of transportation in late 1990s because of the availability of refueling station and the fast refueling processes. If similar recharging stations are available for EVs and the OEMs can meet the expectations of reduced cost and range anxiety, the delay in the adoption of EVs can be reduced. **The survey results also**

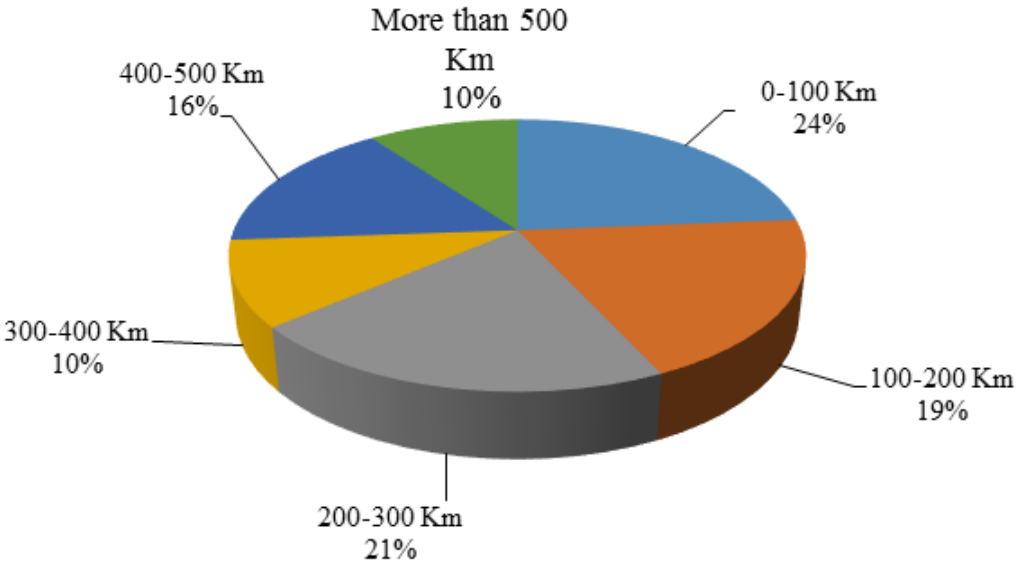
corroborate the discussion as 40% of the respondents stated the lack of charging infrastructure is a considerable concern, followed by other factors like higher price (20-30%) and limited driving range (15-25%).

13.6 EV in Rural scenario

The expectations of rural populations, when compared to the urban population, vary drastically. The technology and the need to transition from ICE-based vehicles to EVs are not major concerns. The rural population looks into the price of the vehicle and the reliability (least maintenance) as a deciding factor. Further, the ease to refuel is also looked into as a criterion for deciding the type of vehicle. **The survey in the rural population showed that the population pictures the EV charging at home rather than a planned charging station.** Hence, the infrastructure requirements in rural and urban vary. The charging infrastructure for the rural area has to be extended to every home.

The other concerns are the prices of the vehicle. The rural population prefers vehicles that simply meet the expectation to commute, transport loads, and meet the day-to-day requirements. Hence, to propel the transition from ICE-based vehicles to EVs, EVs' price needs to remain competitive with the ICE-based vehicles. **Further, the electricity service provider should ensure appropriate infrastructure at every home for ease in recharging EVs.**

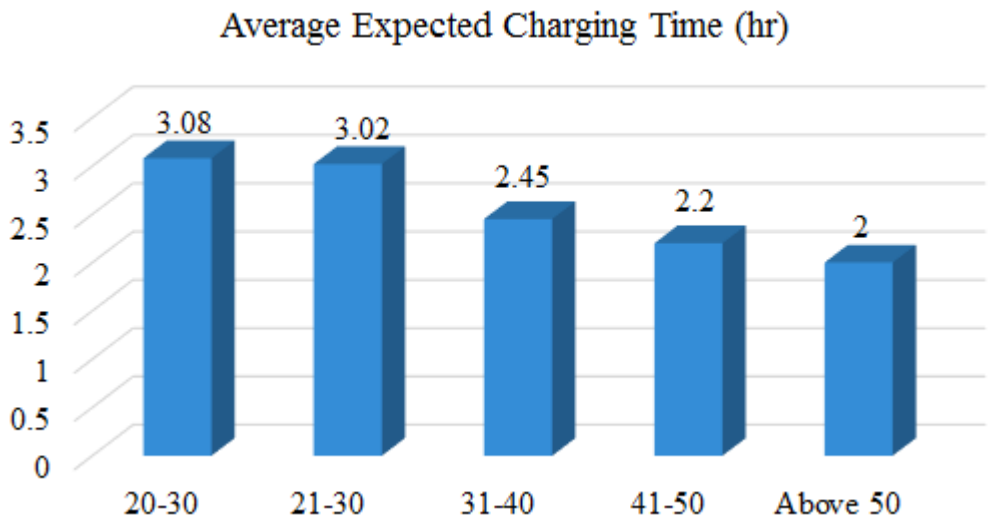
13.7 Range per hour of recharge

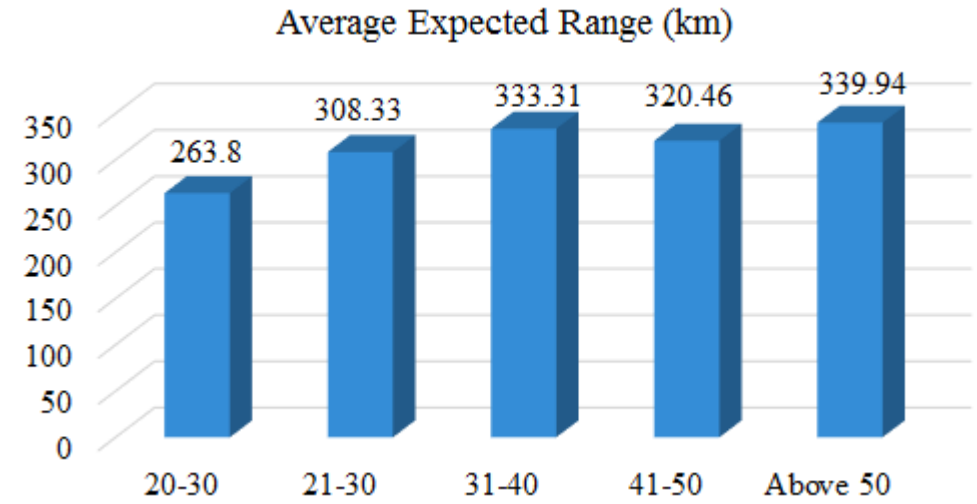


The challenge of ensuring more considerable distances from a single charge is usually termed as range anxiety. The range anxiety is in one way related to the challenge of fast charge as well. Even the ICE engine has a limited fuel tank which allows the vehicle to be driven for a limited distance. However, the refueling of ICE-based vehicles is very fast, which solves the challenge of range anxiety. Further, there are possibilities to carry fuels of ICE-based vehicles in containers, but in EVs, an infrastructure or an energy generating source is

required. Hence, the survey extended to determine the requirements of current and prospective EV users concerning the expected distance coverage from a single charge. Since the range will vary for the types of EVs, viz. 2-wheelers, 3-wheelers, and 4-wheelers, multiple options ranging up to more than 500 km are given.

The value of range per hour of recharge resembles the rate of charging in EVs. A faster charging will result in a more rapid transfer of energy to EVs batteries in less period while a slower would result in the vice-versa. If 100 km per hour of recharge is considered a base value, the survey responses showed that the overall expectation is higher by 64.53 %. The challenge in meeting the requirements of fast charge depends on the change in battery electrochemistry and the availability of rapid charging points. Researches are going worldwide to develop battery electrochemistry which can recharge faster with the least degradation per cycle of recharge and discharge. **The fast-charging points are a concern of the electricity service provider. If these two are solved, the possibility to meet the expectation will increase.**



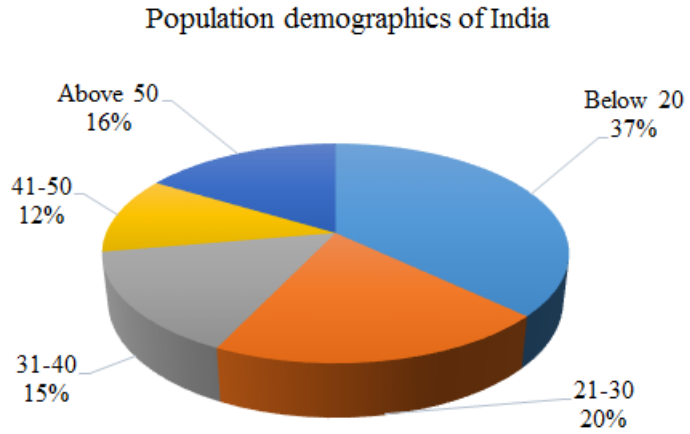


The EV customers are often worried about the vehicle's capability to reach point B from point A before the battery runs out. This issue is closely connected to the inadequate charging infrastructure and time to recharge the bat-

tery in India. **According to the survey, the average range of people prefers to have 314.29 km of range with an average charging time of 2.71 hours.** Both the tasks are individually possible to achieve but combining these two factors is very difficult.

13.8 Correlation of adoption of EV with age

Age is a factor that affects the adoption of newer technology. It is believed that the younger age group is always eager to explore and do experiments.The results obtained in the survey are also in line with the stated. Correlation is figured out between age and the willingness to opt for EVs. **The correlation coefficient is found to be -0.7898, which shows a good negative correlation between the willingness to adopt EVs and the age of the respondents.** It is to be noted that in the process of calculation of the correlation coefficient the opinions of the respondents have been weighed according to the Demographics Profile of India 2016 (as per https://censusindia.gov.in/) age wise.



Henceforth, it is inferred that for the respondents whose age is below 30, the possibility to adopt EVs is higher, while with an increase in age after 31, the possibility to adopt EVs decreases. We can further extend the inference to state that the sale of EVs and their usage in the next five years will depend on the age group up to 35 years. However, the other expectations of this age group of below 30, like fast charging and ease to access recharging, should be met. As per the survey, the age group expects a charging time of fewer than 3 hours and an average range of 300km in a single charge. Further, 64% of the respondents in this age group are also confident over the technology, leading to their agreement to pay 10% to 20% higher prices for EVs compared to ICE-based vehicles.

14 Conclusion

With all the buzz circulating around the electrification of the transportation sector, there is also a need to understand the consumers' acceptance of this new technology. This report provides an extensive analysis of the public's view of electrification, its expectations, challenges, and consequences. With only 10% of the survey participants owning an EV, which might decrease if we

project it to the whole population and consider Heavy-duty vehicles, India is still far behind in penetrating EVs. We might see a better penetration in the future with the decrease in the cost of Li-ion batteries and the Union transport minister announcing the plan to install at least 2700 EV charging stations in Major Highways and government framing a policy allowing petrol pumps to set up EV charging stations.

Despite all this massive potential for EVs, there is still a dire need for public awareness to consider buying an EV, as this dynamic transition in technology is very new and rapid. So, this survey analysis indirectly emphasizes the customer's situation towards adapting to the EVs and presents one of the significant hurdles for policymakers to consider. Although there are substantial fluctuations and unpredictability in the EV market, there is a massive growth of 200% every month and an eight-fold jump last year in two-wheeler EV sales. We also anticipate this will happen in India, as a dominant two-wheeler country, and also the survey shows that 54% of the total electrical vehicles owned are two-wheelers. **This positive trend towards growth indicates the customers' willingness to adapt and accept the challenges posed by the EVs if they are available at a reasonable price.** There are still many uncertainties from the consumer's end which remain unanswered, and the targets of net zero emissions from the government's end remain unattainable. There is still significantly less intervention from state and central governments into making the transportation sector carbon-free.