An Empirical Study of Piezoelectric Cars in India

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Abstract
This paper presents the analysis of the responses of the population sample towards the acceptance of the bleeding edge technology piezoelectric car in India. Piezoelectric car embedded with the piezoelectric material can generate electricity of its own while the car is in motion. Since electric vehicles was not a great success in India due to its limitations, considering the Air Quality Index of India and the greenhouse effect it is high time to introduce an alternative vehicle which would be a viable replacement of the cars which runs on fossil fuels and the hybrid cars.

Keywords— piezoelectric cars, electric cars, air quality

1. Introduction
Electric vehicles (EVs) have been around us for decades. It is said that the abundant supply of fossil fuel will come to an end, bringing down the economic order as well. At the current rate of production, oil will run out in 53 years, natural gas in 54 and coal in 110 years [Siddharth Singh, 2015]. Because of the shortage of fossil fuel products like Petrol and Diesel, their cost and limitations in supply have encouraged commuters to look at EV’s as a possible alternative mode of transportation. In USA, due to the growing concern for air quality and the possible consequences of the greenhouse effect, some cities have set aside emission-free zones and have enforced stricter emissions regulations encouraging the promotion of EVs. In October 1990, the California Air Resources Board established rules that mandates 2% of all vehicles sold in California in 1998 to be Zero Emission Vehicles (ZEV), and by 2003, ZEV sales quota was 10%. Hence, a significant transition from research into development occurred at major automobile manufacturers [Chan CC, 1993]. In 2013 India unveiled “National Electric Mobility Mission Plan (NEMMP) 2020” which addressed on the issue of vehicular pollution. Posterior to the address, Government of India made plan for a major shift towards electric vehicles in India [PIB, 2013]. Some of the full electric cars available in India are Eddy Current Controls, Love Bird, Mahindra e2oPlus, Mahindra e-Verito, Tata Tigor Electric, Mahindra e-KUV 100, Tata Tiago Electric.

Due to every growing air pollution in India due to the emission of harmful gases there is
an immediate need to minimize the use of fossil fuels in vehicles. One of the main reasons for greenhouse effect is due to the harmful emission of CO2 as a by-product from the vehicles. (Makki. et al, 2011)

Taking into consideration the current scenario of India, we do not see a lot of electric vehicles around us. Electric cars did not gain much popularity in India because of its price and the major challenge faced by the electric vehicles is the charging infrastructure. In India charging infrastructure for electric vehicles has not been fully developed yet. There have been initiatives to set up community charging stations, as in the case of Plugin India facilitated charging station. Charging infrastructure, mainly setting up of level 2 charging at public level shall be the toughest challenge in terms of service integration for India. For fast DC charging; cost & high renewable energy are the biggest factors. It is also assumed that 10% of the charging infrastructure required in India shall be composed of fast charging station and rest 90% shall come from level 2 public charging setups [Alam M.Saad, 2018]. With the rise of population in India setting public charging stations in urban area mostly in the populated cities is a major challenge. To cope up with the challenge there is a need of an electric vehicle with a continuous power supply.

Electric vehicles use battery to supply energy to make the vehicle move. But the batteries used in the electric vehicles have limited power which means the battery powered vehicles can only be used for short trips. However Hybrid cars mitigate this problem since they can use conventional use of fuels for internal combustion which recharges the battery which helps the hybrid car to run longer than usual. But the use of hybrid cars challenges the purpose of having electric vehicles which would reduce the environmental impact with the use of renewable energy. There is a need to generate more power taking into account the environmental impact.

Here the need of piezoelectric vehicles comes into play. The concept of piezoelectricity is the accumulation of electric charge in certain solid material in response to applied mechanical stress.[Kunchala Anil,N.Sreekanth,2014] The piezoelectric effect is the change of polarization under the applied mechanical stress or pressure. Piezoelectric materials undergoing continuous mechanical stress are not subjected to same wear and replacement requirement is minimal. The concept of this piezoelectric car would to mount piezoelectric material in all the four tires of the vehicles. As the car drives the tire undergoes mechanical stress since the downward pull of gravitational force it leads the tires to bend and the piezoelectric material undergo mechanical stress which produces alternating current. The amount of pressure that we are dealing with is only transitory, since the vehicle is a moving object. The mechanical energy stored in the piezoelectric disc is increase linearly with the applied force and thickness of the piezoelectric material.[ Kunchala Anil, N.Sreekanth,2014]. If piezoelectric technology is embedded into the vehicles, the vehicle can run on electricity subjected upon mechanical stress which can run billions of cycle without showing the sign of fatigue. This would help the car to travel miles without suffering the loss of power in the middle of nowhere.

This model has a limitation when the car comes to halt. There will be a need of driving force to make the car to bring into inertia of motion. So the modified version of piezoelectric car model would be fitted with rectifiers which would converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one
direction. We would be able to store the energy into ultra-capacitors since it can is impossible for steady current to flow across a capacitor. So to bring the car into motion we can use the stored energy in the ultra-capacitors whenever required (M.Keck 2007). Basically the car would run on electricity which is continuously supplied from the piezoelectric substance and when the car is in rest, to bring the car in motion the vehicle would take energy from the ultra-capacitors. The ultra-capacitors would be recharged fully within an hour or two.

Thus piezoelectric cars would subdue the requirement of fossil fuels in running cars and will eventually help in mitigating the air pollution levels across the globe. In India and in several developing countries, the air quality has deteriorated significantly making it harmful to breathe. Many places in most parts of India have AQI scores showing high levels of pollution which is a matter of concern. According to the Air Quality Index Report February 2019, the quality of air in Ahmedabad shows a value of 335 which is indexed as severe. The price of the fossil fuels is off the charts and lack of charging infrastructure for normal electric vehicles including the challenges to build it, we can establish the fact that piezoelectric vehicle is a viable replacement of not only of the cars which uses fossil fuels to run but also the hybrid cars and electric cars.

The main purpose of the research is to create need and awareness in customer’s mindscape and to get an insight about the exact timeline when to launch this new technology in India.

2. Objective of the Study

i) To identify influential factors for buying piezoelectric cars in India.

ii) To get the exact timeline of acceptance of piezoelectric cars in India after it is launched in the market

iii) To get an insight at what price range should we launch the piezoelectric cars to attract more potential customers.

iv) To create awareness among the people about this new technology.

3. Methodology

A survey was conducted across various cities in India. A sample of 200 respondents is taken into consideration in this project. Snowball sampling technique was used to collect data across the country. Since we are dealing with a bunch of statistical data that is not based solely on parameterized families of probability distributions so Chi square test was done to prove that the distribution of responses collected is not significantly different from the responses of the national survey. Scree plot was plotted to find out the number of factors which can be considered for factor analysis. Cross tabulation was used to compare variables and to bring out the following inferences through graphical representation of the data

4. Analysis

Non parametric Chi square test was to done show to find if there is a significant relation between the sample data collected and the national survey.
TABLE-1- Hypothesis test summary

<table>
<thead>
<tr>
<th></th>
<th>Null Hypothesis</th>
<th>Test</th>
<th>Sig.</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The categories of RESPONDENTS (as defined by you)</td>
<td>Chi-Square</td>
<td>0.00</td>
<td>Reject the null hypothesis</td>
</tr>
<tr>
<td>2</td>
<td>are not homogeneous</td>
<td>Chi-Square</td>
<td>0.72</td>
<td>Retain the null hypothesis</td>
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<tr>
<td>3</td>
<td>Influence of age</td>
<td>chi-square</td>
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<td>Reject the null hypothesis</td>
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<td>4</td>
<td>Influence of age</td>
<td>chi-square</td>
<td>0.00</td>
<td>Reject the null hypothesis</td>
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<td>5</td>
<td>Influence of age</td>
<td>chi-square</td>
<td>0.00</td>
<td>Reject the null hypothesis</td>
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<td>6</td>
<td>Influence of age</td>
<td>chi-square</td>
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<td>Reject the null hypothesis</td>
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<td>7</td>
<td>Influence of age</td>
<td>chi-square</td>
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<td>Reject the null hypothesis</td>
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<td>8</td>
<td>Influence of age</td>
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<td>9</td>
<td>Influence of age</td>
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<td>Reject the null hypothesis</td>
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<td>10</td>
<td>Influence of age</td>
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<td>11</td>
<td>Influence of age</td>
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<td>12</td>
<td>Influence of age</td>
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<td>13</td>
<td>Influence of age</td>
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<td>14</td>
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<td>15</td>
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<td>18</td>
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<td>19</td>
<td>Influence of age</td>
<td>chi-square</td>
<td>0.00</td>
<td>Reject the null hypothesis</td>
</tr>
</tbody>
</table>

H0- The observed distribution is not same as the expected distribution which resembles the national survey.

H1- The observed distribution is same as the expected distribution which resembles the national survey.

The significance value of 18 variables is less than 0.05, so we reject the null hypothesis that the sample taken into account resembles the national survey.

To find the internal consistency of the variables, reliability analysis was carried out.

The value of Cronbach’s alpha observed was 0.767 which has an acceptable internal consistency and it shows the group of variables is somewhat closely related to each other.
Fig-1- Scree Plot

Scree plot helps us to determine the number of factors to be retained for factor analysis. From fig-1 we can see that the elbow shape is forming from the Eigen values 1.25. So the number of factors which can be retained as significant is 2. The total contributing variance is 62.536%. From the 3rd factor the variables are contributing to smaller total variances.
Factor analysis condensed 8 variables into 2 representative variables/factors that are highly inter-related. These 2 factors help in defining the underlying structure of other variables. The new representative factor form is the timeline to buy piezoelectric vehicles on the basis of fuel efficiency.
From Fig-3 we can observe that the variables taken into consideration are very well organised into the common factor space.

The influential factors which the citizens of India feel that affects their psychology of buying a new vehicle, from Figure-3, we can visualize from the bar graph that the top 4 parameters which the consumers look into is Performance, Fuel efficiency, environment friendly and price. These are the performance standards and the specification limits the consumer looks into when they think of buying a car. So the main challenge of the piezoelectric car is to meet all this criteria to hit the customer’s mindscape.
Fig – 4 Percentage of people owning electric vehicles

From the pie chart we can clearly see that 92% of the total population of India doesn’t possess electric vehicles due to its limitations. This creates a great potential for piezoelectric cars to capture the market by taking control of the limitations.

Fig-5- percentage of people preferring piezoelectric vehicle

From figure-5 we can clearly define that 87% of the population of India would prefer piezoelectric vehicles over electric vehicles so it’s high time to introduce this new product into the market.
From figure 6 we can depict that the main benefits of piezoelectric vehicles are Fuel economy, Produces less carbon emission and reduce dependency of fossil fuels since it will only run on DC power.

From figure 7 we can say that about 63% of the consumers are uncertain whether they would be buying the piezoelectric car in future or not. Since it can be the case that people are unaware of this technology totally and presently it is not available in the other nations as well. But 33% of the total population is very keen to accept this new technology in future.
From figure-8 we can depict that the views of the customer when they are going to buy piezoelectric cars in future. 14% of the population is willing to buy this piezoelectric car within 6 months to 1 year, 26.5% and 17.5% within 2 years and 4 years respectively. Considering the time frame a rough estimation of 58% of the population of India would buy the piezoelectric cars within 4 years from the time of launch.

In figure-9 we can see that around 48% of the total population of India constantly thinks about environment and they try to keep it clean and 38% of the people think about the environment a lot of times. Since the cars which use fossil fuels causes a major impact on the ecosystem and degrades the air quality so this percentage of people from India would like to accept the piezoelectric cars instead of cars which use fossil fuels to save the environment from pollution and global warming.
Fig-10- The price range at which the consumers are ready to buy piezoelectric cars

From figure-10 we can see that nearly 44% of the population wants the piezoelectric car price range to be within 8 lakhs and 34% of the population wants it to be priced within 8-12 lakhs. So optimally if the price range is within 8-12 lakhs. There is a possibility to gain around 48-50% of the population as a potential customer for the piezoelectric cars.

Fig-11 – How much consumer would like to pay if they are buying the piezoelectric cars?

The graphical representation shows that majority of the population would like to buy the piezoelectric cars within the range less than 8 lakhs and certainly 8 – 12 lakhs. So basically if the car is priced within 12 lakhs it can attract potential customers.
About 33% of the total population is ready to buy piezoelectric car within 2 years from the day it is launched in the market.

In fig-13 cross tabulation we can see that 34% of the Indian population is ready to accept the piezoelectric cars if it is launched at a price range of 8-12 lakhs of rupees.
5. CONCLUSION

The research was done for the sole purpose to find whether it is feasible to launch the piezoelectric cars or not. Considering the limitations of cars which use fossil fuels and electric cars we can establish the fact that piezoelectric cars are viable replacement. The sample of 200 respondents which represents the population of the country shows there is a degree of inter-correlation among the dependent variables using the Bartlett test of Sphericity. The number of factors generated that was shown by the scree plot was 2. The 2 representative variables are highly inter-correlated with the other variables. 92% of the total population of India doesn’t possess electric vehicles due to its very limitations and they still rely on the cars which uses fossil fuels. 33% of the total population is ready to buy piezoelectric cars and around 62% of the people is uncertain whether to buy it or not. If we assume that electric cars > fossil fuel driven cars based on performance, fuel efficiency and environment friendly then it can be concluded that 87% of the total population would prefer piezoelectric vehicles over electric vehicles. The price range at which the consumers are eager to buy this car is within 12 Lakhs. The statistical data shows that within 4 years of the launch around 60% of the population would be interested to buy this car. This shows that the consumers of India is ready to accept this new technology and when it comes in the market people would definitely buy piezoelectric cars within the specified price range.

6. REFERENCES


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