Examining the Opportunities and Problems associated with Electrification of Vehicles in India by 2030 – a Perception Study

Dr.Usha Devi.N
Associate Professor, MLA First Grade College for Women, Bangalore

Received: February 06, 2019 Accepted: March 20, 2019

ABSTRACT: *Survey method is adopted in the present study. To carry out the investigation, the structured questionnaire technique was used to get insight about the issues explored in the study. The study conveyed that the successful implementation of the Electrification of vehicles in India is not an easy task. The success depends on the whole-hearted support, involvement and the willingness of the people to change and adapt. They have to come out of their illusionary comfort zone. The government should understand the mood of the people, educate them and then implement the rule.*

Key Words: *EVS (Electric Vehicles), PEVS (Plug-In Electric Vehicles)*

THEORETICAL SETTING:

Over the years, the exploitation and pollution of natural resources have created the need for renewable and environment-friendly products. One of these products is Electric Vehicles. Electric Vehicles are the replacement for petroleum-based vehicles.

India currently has around 1.3 billion people with around 21 million vehicles sold annually [7].The Government of India is planning to introduce Electric Vehicles by 2030 in order to cut its oil purchases by $60 billion and to reduce emissions by 37% [9]. It is envisaged that EVs are expected to play a significant role in India's transition to a low-carbon eco-system

The transport sector is the largest user of oil and second largest source of CO2 emissions world-wide. Indian transportation sector accounts for one-third of the total crude oil consumed in the country with 80% of this being consumed by road transportation alone. It also accounts for 11% of total CO2 emissions from fuel combustion. As per the National Electric Mobility Mission Plan 2020, notified by the Ministry of Heavy Industries and Public Enterprises, Government of India seeks to enhance national energy security, mitigate adverse environmental impacts from road transport vehicles and boost domestic manufacturing capabilities for Electric Vehicles [1].

Distribution Licensees and Electricity Regulatory Commissions are the critical stakeholders in the EV landscape. As more EVs populate roads, distribution licensees play a significant role in managing these 'mobile assets'. Therefore, Distribution licensees need to be informed about the benefits that they can derive from EVs and about the innovative mechanisms that they can devise to avoid adding stress to the grid from charging of EVs. Distribution licensees should not perceive EVs as an additional burden on the grid, which could hinder the large-scale adoption of EVs. [2].

Similarly, regulators need to create an enabling framework and attractive rate structures for charging, such that peak hour charging is avoided and is shifted to off peak hours. Hence it is very important to equip both regulatory and utility personnel with the technical and managerial aspects of the EVs landscape [3].

Global scenario

In Japan, China, California, France, US, government is the main driver for EV development and supports every stage of the system from R&D, demonstration and promotion, commercialization to production and sales and charging infrastructure construction.[4]. Further, the government provides subsidies towards the purchase of all-electric vehicles and plug-in hybrids with low CO2 emissions [5].

Indian scenario

According to Rocky Mountain Institute (RMI) report, electric mobility will save India from 1 giga-tonne of carbon-dioxide emissions by 2030. Further, the country can boost its economy by saving 876 million tonnes of oil equivalent worth Rs 20 lakh crore [6].

Automobile major Mahindra & Mahindra (M&M) Chairman said that the concept of making environment-friendly and clean technology vehicles is business opportunity of future that can allow businesses to make

money out of the nascent sector. M&M and Tata Motor will jointly supply 500 electric vehicles in phase I to State-run Energy Efficiency Services Limited (EESL) by November 2030.The purchase orders for supply of the rest of 9,500 electric vehicles is scheduled for the phase II.[8]

It is estimated that India's urban population will be approximately 600 million in 2030 and India's urban population will be 500 million trips per day. This rapid growth presents major policy and business challenge for India's public and private transport sectors [7].

Review of literature:

Literature review was done using a comprehensive search tool like academic search complete, business source complete, ERIC as well as other relevant databases such as Pro Quest, Psyc INFO, and JSTOR. The search was limited to peer-reviewed and English language articles. The following key terms were used in the advanced search engines: electric vehicles and Plug-in electric vehicles. These terms were used independently, as well as in combination with each other.

The overview of the related literature on* Electrification of vehicles *is enunciated below:

- Blue Green Alliance/American Council for an Energy-Efficient Economy estimated that the average buyer for PEV will be: Around 45 years old, owns a home and a garage, Makes about $125,000 a year, is collegeeducated, and already owns a fuelefficient vehicle.[11]
- Surveys by the University of Michigan and Pike Research found that the more education a person has, the more likely he or she is to be interested in purchasing a plug-in hybrid vehicle. Those with higher income are also more likely to purchase a PEV.[12]
- Electric vehicles are an additional source of revenue for electricity distribution companies and with proper planning, can result in more efficient and less costly operation of the grid. EVs will also provide ancillary services, lower electricity prices for ratepayers and facilitate greater integration of renewable energy resources.[13]
- Deloitte survey found that even these early adopters are sensitive to government incentives and overall cost considerations. Thus, communities that adopt charging infrastructure and offer purchase incentives can strengthen their appeal to these educated, wealthier workers.[14]
- Greater adoption of PEVs will create rising demand for existing jobs and produce opportunities for new types of jobs as well. Among PEV industries, battery and charging infrastructure will likely generate the most new jobs. Although there may be some job losses in the oil and conventional car industries, study after study confirms that the result will be net job growth. [15]
- Electrification of personal transportation can drive job creation in a host of industries. More efficient automobiles require more technology, which are designed and produced by adding workers to the auto industry. Many of these jobs would be created in industrial sectors closely tied to auto manufacturing, advanced batteries, and research and development.[16]
- Drivers who switch to electric vehicles will have more disposable income to spend in other sectors of the economy, such as housing and services. Spending in these sectors keeps more wealth moving within local economies and will drive job creation in sectors not immediately connected to producing electric vehicles.[17]
- Direct jobs are created through increased production by firms that make PEVs, PEV components, and PEV infrastructure. Indirect jobs are those tied to firms that supply to these direct producers. Further, higher employment in direct and indirect jobs leads to more spending in the broader economy. These create induced jobs in industries like food, clothing, and entertainment. [18]

Statement of the problem:

Government of India has formulated a scheme, titled Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India, under the National Electric Mobility Mission Plan 2020, to encourage the progressive induction of reliable, affordable and efficient electric and hybrid vehicles. Therefore, considerable growth is envisaged in the EVs market with greater adoption of EVs in India. It is also envisaged that greater adoption of EVs in India would have a considerable impact on the electric grid.

But, the electrical vehicle load is non-linear and can cause harmonic distortion, DC offset, phase imbalance and voltage deviations in the distribution network. Again, India does not have enough lithium reserves for manufacturing lithium-ion batteries, which is used as a key raw material for EVs. This could lead to a substantial change in the country's energy security priorities. Therefore, the present study is undertaken, where an effort is made to the study of the perception of people about adoption of electric vehicles in India.

Objectives of the study:

1. To study the perception of Bangaloreans about adoption of EVs by 2030
2. To analyse the association between Socio-demographic factors and perception of the Bangaloreans towards EVs by 2030

Hypothesis

1. There is association between Age and Perception of Bangaloreans towards EVs by 2030
2. There is association between Gender and Perception of Bangaloreans towards EVs by 2030
3. There is association between Qualification and Perception of Bangaloreans towards EVs by 2030
4. There is association between Occupation and Perception of Bangaloreans towards EVs by 2030
5. There is association between Income and Perception of Bangaloreans towards EVs by 2030

Operational Definitions

- **Hybrid Electric Vehicles:** Electric vehicles that employ both electric and gas power. The onboard battery helps gas to be used more efficiently, while gas recharges the battery.
- **Battery Electric Vehicles (BEVs):** Electric vehicles that are solely electricity-powered and have no backup fuel source.
- **Extended-Range Electric Vehicles (EREVs):** A vehicle that is powered by battery for a certain number of miles. Gasoline then powers an electric generator for the next several hundred miles of extended-range driving.
- **Plug-In Hybrids (PHEVs):** A subset of hybrids that allows batteries to be recharged by plugging into an external electricity source. PEVs can operate on a combination of electricity and gasoline, depending on the vehicle's configuration and power needs.

Methodology and Sources of data

The research study is empirical in nature, where quantitative research was used for data gathering and analysis. The study was conducted through a survey method. To carry out the study, the structured questionnaire technique was used to get insight about the issues explored in the present study.

For the purpose of the study, primary data is collected from the people who are graduates and residing in Bangalore and aware of government decision regarding electrification of vehicles in India by 2030. The secondary data was collected from websites.

Sampling Design

This study is based on data collected from 607 graduates residing in Bangalore and aware of government decision regarding electrification of vehicles in India by 2030. The study followed judgement sampling design. Selected graduates were randomly approached to fill in the developed questionnaire.

Development of Scale

Based on the review of literature and detailed discussion with experts, a questionnaire was prepared. Five Socio-demographic factors and 25 statements on opportunities and problems of EVs were included in the questionnaire.

Scale validation

Exploratory Factor Analysis

The survey questionnaire' validity was tested using Exploratory Factor Analysis (EFA). The primary EFA was run on 30 items. The results of EFA indicated five factors namely quality of life, environment friendly, user friendly, and cost and revenue factors. The five factors are consistent with 26 items. However, the exception of 4 items, which had a cross loading. Thus, the present study removed those 4 items to finally validate the questionnaire. After removing the 4 items, the findings of EFA showed that the extent of inter-correlation among the items is statistically significant. The Kaiser-Meyer-Olkin measure of sampling adequacy was .873, indicating the adequacy of the data for EFA. Bartlett's Test of Sphericity was revealed to be statistically significant ($p = .000$), which indicates the satisfactory correlation between the items.

Confirmatory Factor Analysis

Confirmatory factor analysis uses construct validity to prove that the instrument is valid and reliable.

Construct Validity: construct validity includes the following: convergent validity, discriminant validity, face validity and nomological validity.

1. **Convergent Validity:** Convergent validity includes three indicators: significance of factor loading, reliability analysis, composite reliability and average variance extracted (AVE).

- **Significance of Factor Loading:** The value of factor loadings (λ), should be statistically significant and larger than minimum threshold of 0.70. (Fornell and Larcker, 1981, Hurley *et al.*, 1997).
- **Reliability Analysis:** Cronbach's Alpha coefficient is a value for reliability having values from zero to one. Its higher value indicates greater reliability. Generally, scholars use 0.7 as a minimum level *(Jolibert & Jourdan, 2006).*
- **Composite reliability:** Composite reliabilities should be greater than 0.80 (Fornell and Larcker, 1981, Hurley *et al.*, 1997).
- **Average Variance Extracted:** average variance extracted for all the measurement items should be higher than minimum threshold of 0.50 (Fornell and Larcker, 1981, Hurley *et al.*, 1997).

2. **Discriminant Validity:** The study uses the Fornell and Larcker (1981) typology to assess the discriminant validity. This approach suggests that "average variance extracted (AVE) for each constructs should be larger than squared correlation between the same constructs and any other constructs"
3. **Face Validity:** The opinions expressed by experts were obtained to measure the face validity of the questionnaire. After analyzing the results, researcher found that the items included in the study were suitable for inclusion in the scale.
4. **Nomological Validity (Non-Logical Validity):** Defined by Cronbach and Meehl, this is the set of relationships between constructs and between consequent measures. The relationships between constructs should be reflected in the relationships between measures or observations. In the present study, the correlation matrix of all the possible linkages among the constructs found as per the law of nature. Hence, nomological validity ensured (refer Table 2).

Table-1: Convergent Validity Test

Constructs	Measurement items	Standard Loading	Cronbach Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Quality of Life	QOL1	0.87	0.98	0.91	0.74
	QOL2	0.84			
	QOL3	0.77			
	QOL4	0.87			
	QOL5	0.88			
	QOL6	0.81			
Environment friendly	EF 1	0.86	0.90	0.84	0.67
	EF 2	0.87			
	EF 3	0.81			
	EF 4	0.77			
User friendly	UF 1	0.78	0.90	0.83	0.69
	UF 2	0.83			
	UF 3	0.77			
	UF 4	0.87			
	UF 5	0.88			
	UF 6	0.76			
	UF 7	0.78			
	UF 8	0.81			

	UF 9	0.73			
Cost	C 1	0.86	0.72	0.91	0.74
	C 2	0.76			
	C 3	0.78			
	C 4	0.81			
Revenue	PB4	0.81	0.81	0.84	0.69
	PB5	0.83			
	PB6	0.78			

- In this study researcher used Cronbach's alpha to measure the reliability of statements. The Cronbach alpha values for the five constructs exceed the recommended value of 0.70, which demonstrates that the instrument is reliable.
- In the present study, the loading items (λ) lie between 0.73-0.91, composite reliabilities ranges from 0.80-0.95 and values of AVE come between 0.61-0.74. The results indicate that measurement model meets the criteria of convergent validity.

Table 2: AVE and square of correlations between constructs

The study uses the Fornell and Larcker (1981) typology to assess the discriminant validity.

	Constructs	1	2	3	4	5
1	Quality of life	**0.86**				
2	Environment friendly	0.55*	**0.81**			
3	User Friendly	0.62*	0.42*	**0.78**		
4	Cost	0.64*	0.51*	0.42*	**0.83**	
5	Revenue	0.56*	0.51*	0.43*	0.42*	**0.86**

Diagonal Value: Square root of the AVE, Non-diagonal value: Correlation

Table 2 highlights that square root of average variance extracted is greater than correlation of constructs (square root of AVE > correlation of constructs), hence discriminant validity is established. So, fulfilment of both convergent and discriminant validity test lead to better constructs validity to proceed for further analysis

Table- 3: CFA Results for Model Fitness

To measure the goodness of fit of the measurement model, author used seven goodness-of-fit (GoF) measures namely GFI, RMSEA, NFI, AGFI, CFI, PGFI and PNFI and the results are as follows:

Fit index	Scores	Standardized cut-off value
Absolute Fit Measures		
χ2/df	2.858	≤ 2[a]; ≤ 5[b]
GFI	0.860	≥ 0.90[a]; ≥ 0.80
RMSEA	0.053	< 0.08[a]; < 0.10
Incremental Fit Measures		
NFI	0.780	≥ 0.90[a]
AGFI	0.843	≥ 0.90[a]; ≥ 0.80[b]
CFI	0.844	≥ 0.90[a]
Parsimonious Fit Measures		
PGFI	0.768	The higher, the better
PNFI	0.734	The higher, the better

Notes: Acceptability Criterion: [a]acceptable; [b]marginal

(GFI = goodness-of-fit index; RMSEA = root mean square error of approximation; NFI = normed fit index; AGFI = adjusted goodness-of-fit index; CFI = comparative fit index; PGFI =parsimony goodness-of-fit index; PNFI = parsimony normed fit index)

Results:(1) absolute fit measures: *X2/df* = 2.858, GFI = 0.860, RMSEA = 0.053.
(2)Incremental fit measures: NFI = 0.780, AGFI = 0.843, CFI = 0.844.
(3) Parsimonious fit measures: PGFI = 0.768, PNFI = 0.734.

Table 3- presents the overall fit indices of the CFA model with scores and recommended cut-off value, suggesting that all values meet satisfactory levels of fit indices, confirming that model is fit and hence is suitable for testing the proposed hypotheses.

Data Tools for Analysis and Interpretation

In this study, percentages, standard deviation and chi-square analysis is used to study the perception of Bangalore residents about opportunities and problems of Electrification of vehicles in India by 2030.

I. RESEARCH FINDINGS

The major findings of the study are summarized below:

Objective-1: To study the perception of Bangaloreans towards EVs by 2030

Table –4: Perception of the Bangaloreans towards EVs (mean percentage)

No.	Variables	Statements	Max. Score	Response		Mean (%)
				Mean	SD	
1.	Quality of life	06	30	21.39	4.4	71.3
2.	Environment friendly	04	20	14.46	7.4	72.3
3.	User friendly	09	45	30.60	9.8	68.0
4.	Cost	04	20	14.00	9.7	70.0
5.	Revenue	03	15	11.00	2.7	73.4

* Significant at 5% Level

Min. Score = 1 Max. Score = 5 Overall mean percentage = 71.00

Mean Percentage = Total mean score / Max. Score * 100

It is evident from the findings that the mean percentage showed highest in the aspects of revenue (73.4%), environment friendly (72.3%), and quality of life (71.3%), as compared to overall mean percentage (71%). This conveys that people have faith in EVs, because they have low risk of fires and explosions and are less polluting and produce less noise compared to petrol/diesel based vehicles. Further, the reduced harmful emissions will lead to better air quality, which is good for health.

On the other hand, less mean percentage is observed in the aspects of cost (70.0%) and user friendly (68%). This clearly indicates that the people are willing to buy EVs, if such vehicles are user friendly and price is reasonable.

Objective-2: To study the Association between Socio-demographic factors and Perception of the Bangaloreans towards EVs by 2030

Table – 5: Association between Socio-Demographic factors and perception of the Bangaloreans towards EVs by 2030

N= 207

Sl. No.	Demo-graphic Variables	Category	Sample (n)	Level of Perception				χ^2 Value	Table value
				Low		High			
				N	%	N	%		
1	Gender	Male	155	36	22.3	119	77.7	3.22^{ns}	3.841 (df=1)
		Female	52	19	36.8	33	63.2		
2	Age (years)	25-35	71	21	29.6	50	70.4	8.76*	5.991 (df=2)
		35-45	123	29	23.6	94	76.5		
		45-55	13	06	42.9	07	57.1		

Sl. No.	Demo-graphic Variables	Category	Sample (n)	Level of Perception				χ^2 Value	Table value
				Low		High			
				N	%	N	%		
3	Qualification	UG	100	27	27.0	73	73.0	17.26*	5.991 (df=2)
		PG	74	15	20.0	59	80.0		
		PHD	33	00	00.0	33	33.0		
4	Occupation	Business	100	36	36	64	64.0	3.42^{ns}	3.881 (df=2)
		Employed	52	19	36.8	33	63.2		
		Profession	55	00	00.0	55	100.0		
5	Monthly Income	Rs.15,000-30,000	66	21	30.6	45	69.4	6.22*	5.991 (df=2)
		30,000-50,000	100	34	34.0	66	66.0		
		Above 50,000	38	00	00.0	38	100.0		

* Significant at 5% Level

1) **Gender:** It is evident from the findings that 77.7 percent of the male respondents and 63.2 percent of the female respondents have high level of willingness to adopt EVs. However, the statistical test reveals that there is no significant association between gender and willingness level of the people about EVs ($\chi2 = 3.22^{ns}$).
2) **Age Group:** It is apparent from the findings that 76.5 percent of the respondents in the age group of 35- 45 years have high level of willingness to adopt EVs as compared to 70.4 percent of the respondents in the age group of 25- 35 years and 57.1 percent of the respondents in the age group of 45- 55 years. The data subjected for statistical test revealed that there is a significant association between age group and willingness levels of the respondents ($\chi2 = 8.76$*). *This indicates that the person in the age group of 35-45 years will be the buyers of EVs.*
3) **Qualification:** It is clear from the findings that 73 percent of under graduate respondents have high level of willingness to adopt EVs, as compared 80 percent of the post graduate respondents and 33 percent of PHD holders. The statistical test reveals that there is a significant association between qualification and level of willingness of the respondents ($\chi2 = 17.26$*). *This indicates that the more education a person has, the more likely he or she is to be interested in purchasing electric /hybrid vehicle.*
4) **Occupation:** It can be ascertained from the findings that 64.0 percent of the employees have high level of willingness to adopt EVs as compared to 63.2 percent of the business respondents and 100 percent of professionals. The statistical test reveals that there is no significant association between work experience and perception level of the respondents ($\chi2 = 3.88^{ns}$).
5) **Monthly income:** It is evident from the findings that 69.4 percent of the respondents with Rs.15, 000-30,000 monthly income have high level of willingness about EVs as compared to 66 percent of the respondents with monthly income of Rs. 30,000-50,000 and 100 percent with monthly income of Rs. above 50,000. The data subjected for statistical test establishes that there is significant association between self-income and willingness levels of respondents ($\chi2 = 6.22$*). *This indicates that those with higher income are more likely to purchase electric /hybrid vehicle.*

Implications of the study

Theoretical implications: The findings of the study will facilitate the Government to offer substantial direct and indirect incentives to EVs. For instance, direct incentives like purchase of EVs and installation of chargers at subsidised rates, while indirect benefits ranging from tax breaks to access to reserved lanes and parking spots.

Practical implications: The successful implementation of the rule is not an easy task. The success depends on the whole-hearted support, involvement and the willingness of the people to change and adapt. They have to come out of their illusionary comfort zone. The government has to understand the mood of the people, educate them and then implement the rule.

Electricity distribution companies should play a key role in establishing clear policies for the development of charging infrastructure. Regulators in regulated electricity markets should mandate electricity distribution companies to invest in EV charging infrastructure.

Developing a consumer education plan, Disseminating information on charger locations, Collaborating with private charging station providers, Creating tailored workforce training programs, and supporting supply chain development is required for the successful implementation of Electrification of Vehicles in India by 2030.

Methodological implications: Research can be done through a more comprehensive questionnaire, on a larger scale, with a larger number of respondents over a wider area. This will give more dependable data. The survey can be conducted after sufficient time to allow people to understand more about the implications of the rule.

References:

1. http://www.galvinpower.org/power-consumers/act/real-time-illinois/faq
2. http://www.hybridcars.com:http://www.hybridcars.com/the-world-just-bought-its-twomillionth-plug-in-car/
3. http://www.theicct.org/sites/default/files/publications/ICCT_EVpolicies-Europe-201605.pdf
4. http://www.ieahev.org/http://www.ieahev.org/by-country/france-policy-and-legislation/
5. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-future-of-mobility-in-india-challenges-and-opportunities-for-the-auto-component-industry
6. http://niti.gov.in/writereaddata/files/document_publication/RMI_India_Report_web.pdf
7. http://niti.gov.in/writereaddata/files/document_publication/India-Energy-Storage-Mission.pdf
8. https://electrek.co/2017/01/30/electric-vehicle-battery-cost-dropped-80-6-years-227kwh-tesla-190kwh/
9. https://www.ucsusa.org/clean-vehicles/electric-vehicles/electric-cars-battery-life-materials-cost#.Wrx_2_lEnDc
10. http://energyfuse.org/indias-oil-demand-main-engine-global-growth/
11. https://www.hindustantimes.com/india-news/india-beat-china-in-air-pollution-deaths-last-year-greenpeace-study/story-5JUG4bNyaknIYicDWlpccN.html
12. https://www.bloomberg.com/gadfly/articles/2017-09-18/china-electric-cars-run-on-coal-but-are-still-cleaner
13. https://www.altenergymag.com/article/2011/04/india-renewable-energy-market-trends-analysis-and-forecasts/868
14. https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf
15. http://www.fame-india.gov.in/ViewNotificationDetails.aspx?RowId=5
16. https://economictimes.indiatimes.com/industry/auto/news/industry/india-aims-to-become-100-e-vehicle-nation-by-2030-piyush-goyal/articleshow/51551706.cms
17. https://www.livemint.com/Industry/ji96zXi5dZz3L1XUSkiZxM/Indias-electric-vehicle-drive-Challenges-and-opportunities.html
18. https://tradingeconomics.com/india/imports-of-crude-oil
19. http://dhi.nic.in/writereaddata/Content/NEMMP2020.pdf
20. https://www.theguardian.com/environment/2016/feb/25/electric-cars-will-be-cheaper-than-conventional-vehicles-by-2022