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Identification of Attributes in Battery Electric Vehicle using Kano Model in India

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Abstract

As there is scarcity of energy resources, more and more companies in different countries have put lot of attention to clean energy so as to reduce pollution emissions. Now it's crucial to develop battery electric vehicle (BEV) to meet the government and society's demand. It's not easy though as the Electric Vehicle (EV) industry needs to overcome major challenges related to battery technology and charging infrastructure, both of which have failed to match the rapid pace set by BEVs. There are many factors affecting the wide utilization of BEV. It is vital to study customer satisfaction of BEV and find the way to improve customer satisfaction and identify critical factors. As the relationship between product performance and customer satisfaction is non-linear, the Kano model is used to analyze customer needs for the BEV so that the adoption of BEV in India can be encouraged. There are three approaches to Kano model used to categorize the BEV attributes in broadly four categories such as Must-be (M), One-dimensional (O), Attractive (A) and Indifferent (I) quality. As per the strategic rule M > O > A > I, the priorities of efforts towards promotion and adoption of BEV is identified, i.e., government as well as the vehicle firms have to fulfill all the must-be requirements. They should demonstrate phenomenal improvement of one-dimensional qualities to make the battery electric vehicle competitive to the traditional motor vehicles. Finally, the customers will be amazed if the attractive requirements are fulfilled.

Keywords: Attributes, Battery Electric Vehicle, Customer Requirement, Customer Satisfaction, Kano Model.

Introduction

As per air quality indices related to India, the air in many cities of India is no longer healthy. One of the major causes for this will be automobile related pollution. The need of the hour is to reduce dependency on a fossil fuel based economy. India can become a world-wide provider for clean mobility solution and processes that are affordable as well as scalable. People living in some parts of India are being affected by noise pollution. Some of the Indian cities have most horrible noise pollution level in the world. Electric vehicle may contribute to a reduction in noise pollution level in the cities.

Energy efficiency and emission reduction has improved immensely in automobiles. Yet the improvement in total number of vehicles on road resulting total pollution and the total energy consumption removed all gains made by betterment in energy efficiency and emission reduction by automobiles. The Government initiated "Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME)" scheme which offers incentives for purchasing electric vehicles. The incentive is Rs. 1.38 Lakh for cars [38]. FAME is a part of National Electric Mobility Mission Plan (NEMMP) by Government of India. India unveiled 'National Electric Mobility Mission Plan (NEMMP) 2020' in 2013 to address various issues like growth of domestic manufacturing capabilities, National Energy Security and vehicular pollution. Government of India has plans to make a major shift to electric vehicles by 2030 as per its commitment to the Paris Agreement. Government is releasing tenders to increase charging infrastructure in the country. The development of new energy vehicles, particularly battery electric vehicle (BEV), is one the novel way to reduce air pollution [5]. Energy-saving and environment-friendly technology of BEV which is absolutely powered by rechargeable batteries such as lead-acid batteries as well as nickel cadmium batteries. It excels in comfort, lower driving cost and quiet driving performance [7]. BEV will save the oil consumption and reduce pollution emissions by replacing conventional motor vehicles. It's indispensable for the government to support the development of BEV technologies. On the other hand, the firms have to continually improve BEV's performance to meet customers' needs by R&D activities.

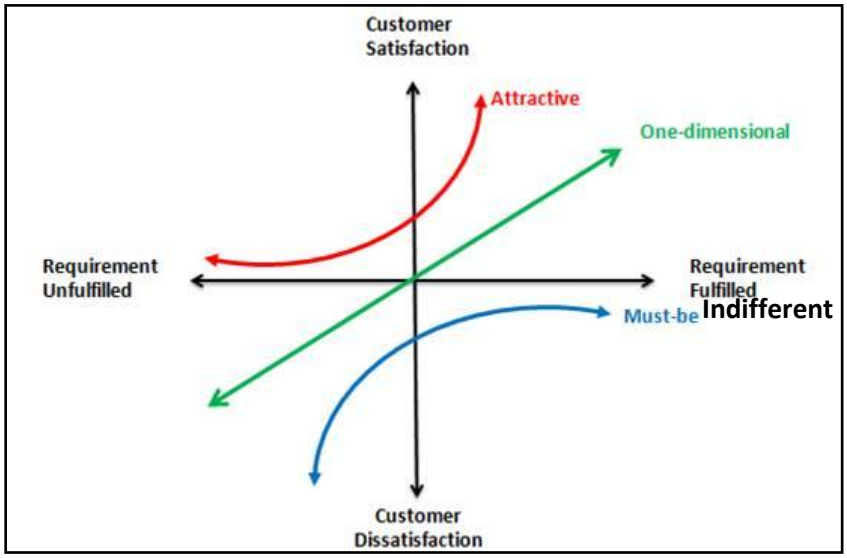
Many studies were keen in finding out factors affecting the purchasing decision of BEV to enhance customer satisfaction, which is considered to be important for product design and development to succeed in the market place [25]. For example, Sierzchula et al. [29] discussed the relationship between the utilization rate of electric vehicles and the fiscal stimulus and other social factors by collecting data from more than thirty countries. It was revealed that presence of local electric vehicle production base, number of charging piles and the fiscal stimulus are associated with the utilization of pure electric vehicles. However, the sufficient charging infrastructures and fiscal stimulus cannot give assurance of high utilization rate of electric vehicles. Mau et al. [24] concluded that customers' preferences on charging facilities, driving range, fuel costs, government subsidies, maintenance, price and service have great effects on the utilization rate of electric vehicles. Based on bass diffusion model and dynamics, Park et al. [27] predicted the impact of price change rate and charging stations on the fuel cell vehicles. In a nutshell, there are many factors affecting the adoption of BEV in practice. Most of the researchers only give emphasis on the analysis of barriers and policies [3, 9, 30], little research has focused on the development orientation and the priority of factors to improve the BEV. It is vital to understand customers' preferences for the adoption of BEV. It is essential to study customer satisfaction of BEV. So we have to ascertain customer' needs, identifying critical factors and finding the way to improve

customer satisfaction. As customers' preferences vary across globe, it is difficult for the firms and government to determine what they should focus on and how to target the potential customers. In general, analysis of customer needs involves three aspects [34]: (1) knowing customer's want and preference, (2) prioritization of product functional requirements and (3) the classification of the functional requirements. In general customer need analysis assumes a linear relationship between customer satisfaction and the performance of product. Kano model [14] combines with hygiene-motivational factors in a different perspective, which is based on nonlinear relationship and it takes psychology of customers into account. The Kano model can categorize customer needs by the common surveys. The main focus of this research is to categorize the customer needs of BEV based on the Kano model. By this way we are using a logical approach to distinguish consumer needs, identifying the key factors so that we can prioritize and find ways to improve customer satisfaction of the BEV. The findings of this research will offer guidance to the firms to make a trade-off of customer satisfaction and cost for research and development. The government can also prepare relevant policies to accelerate the promotion of BEV.

The Kano Model

The Kano model is a theory deals in product development and customer satisfaction which is developed by Professor Noriaki Kanoin 1980s, which classifies customer preferences into five categories.

Figure 1. Kano Model



Source: http://design-cu.jp/iasdr2013/papers/1835-1b.pdf

(a) Must-be Quality -These quality attributes are also known as basic requirements. Even if these qualities got fulfilled, it is not going to enhance satisfaction but if it's not fulfilled, it will generate dissatisfaction. As these attributes are basic requirements of the customers, it is unlikely that they are going to tell the company about them when asked about quality attributes.
(b) One-dimensional Quality - This quality attributes result in satisfaction when fulfilled and dissatisfaction when not fulfilled. These are attributes that are expected by the customers and the ones in which companies compete. If these types of requirements are fulfilled, they generally become a strong source of customer satisfaction and therefore should be given higher priority in designing product and service.
(c) (c) Attractive Quality - These are the attributes that are not expected normally. These quality attributes provide satisfaction when accomplished fully, but if it could not fulfilled, does not create dissatisfaction. Therefore even if these attributes are not met then also they will not cause any dissatisfaction.
(d) Indifferent Quality - These quality attributes do not result in either customer satisfaction or customer dissatisfaction.
(e) Reverse Quality -These quality attributes refer to a high degree of achievement resulting in dissatisfaction and to the fact that not all customers are alike.

Review of Literature

This literature review aim at investigation the important contribution which made use of the Kano methodology. It summarizes and tries making a linkage to suitable school of thought. All the scientific research start with analyzing the existing literature to get a border picture of the world as reported by Cooper (1998) [4]. It's described in three phases.

First Phase (1984-1999)

Kano and Takahashi (1979) [15]studied the concept of the motivator-hygiene (MH) property of quality on the basis of Herzberg´s two factor theory and found that factors crating job satisfaction and job dissatisfaction are different. Kano et al. (1984) [14] introduced their theory of "attractive quality and must-be quality" in the Western world. A new field of research was born with the conceptual basis and the development of the Kano methodology, which comprises a specific questionnaire to categorize quality attributes. Publication of some research papers (Kano 1995[13]; Yamada 1998) [35], which reinforced the dissemination of the theory of attractive quality, also took place. Berger at al. (1993) [2] contributed a collection of ideas of using theory in practices in this field. A case study from NASA was executed by Lee and Newcomb (1997) [16] which presented new means and measures to simplify the classification of quality

attributes and suggested alternative statistical test and procedures for their use in practice. Matzler et al. 1996[23]; Matzler and Hinterhuber (1998)[22] strengthens the foundation for the theory of attractive quality strengthen through a wide empirical investigation in the ski industry (over 1500 customers). The initial 15 years after Kano's theory of attractive quality depended on couple of solid scholarly papers that opened the field of research.

Second Phase (2000-2008)

The number of papers gradually increases as lots of researches were going on application of Kano methodology in different product and services.

In 2001 Noriaki Kano presented a paper titled "Life cycle and creation of attractive quality" in a conference in Sweden (Kano, 2001) [12]. In this paper he examines available remote controls for television in the years 1983, 1989 and 1998. The result he got from the research was quite interesting asin 983, a remote control was an attractive quality attribute, in1989 it becomes a one-dimensional attribute and in 1998 it's a must-be quality attribute. Nilsson-Witell and Fundin released a research paper in 2005[26], which examine the early stage of the life cycle of the attractive quality. The researcher found that new attributes are firstly aphetic before they become attractive. Nilsson-Witell and Fundin (2005) [26] compared the answer possibilities of a Japanese (Kano et. al., 1984) [14] questionnaire with an American (Berger et al., 1993) [2] questionnaire. On the basis of this comparison, Nilsson-Witell and Fundin (2005) [26] ensured that confusing classifications portions were dropped. The satisfaction of customers with a TV service analysed by Jacobs (1999) [11] and the staff satisfaction was evaluated Martensen and Grönholdt (2001) [21]. Both the researches classified the attributes based on their importance with the help of a dual-importance grid while a three-level questionnaire was released by Kano (2001) {12]. Emery and Tian (2002) [6] and von Dranand Zhang (2002) [33] employed direct questions approach.

The traditional method to categorizing attributes was conceived by Kano et. al. (1984) [14] and Löfgren and Witeel (2008) [18] compared this method with some substitute methods in an empirical study. (Martensen and Grönholdt, 2001[21]; Emery and Tian, 2002[6]). However, the study reveals that none of the other methods led to an outcome, which has any parallels with the outcome of the traditional Kano methodology. Moreover, the results from the three-level questionnaire steadily differ from the results of the five-level Kano questionnaire (Löfgren and Witell, 2008) [18].With this knowledge, Löfgrenet. al., (2013) [19] concluded in their literature review, that more exploration of other methods are required and for which they recommended to use the traditional five-level Kano questionnaire. The relation between Kano methodology and other methods, like FMEA, QFD and SERVQUAL was studied by

Matzler and Hinterhuber's (1998) [22]. Mostly a combination of the Kano methodology and QFD is used. Tan and Shen (2000) [32] priorities must be quality attributes whereas Tan and Pawita (2001) [31] priorities attractive quality attributes.

The research which has been done in this stage, studied different methodologies and investigated new fields for the work of the Kano philosophy. The ancillary wordings, methodologies and sorts of investigations ended up being advantageous in light of the fact that they offer range in the order of quality attributes. Be that as it may, the distinction between the options to the traditional Kano methodology is the result since it frequently separates from one another. But the issue is, that the best method is yet to be identified.

Third Phase (2009-2016)

The number of paper published each year increased profoundly as compared to the second Phase (2000 and 2008). While the number of research in other areas increased, the research on the methodological foundations of the theory was limited. A large number of papers instead are using Kano´s model and modify it like the fuzzy approach for a more objective questionnaire (Lee and Huang, 2009)[17] and the modified cross axis of Kano´s model from Shyu et al. (2013)[28]. Högström in 2011[10] challenged the alternative answers, the evaluation table and wording used in questions. Gruber et al. (2011) [8] revisited the study of life cycle of quality attributes, which was introduced by Kano (2001), concluded that the attributes of service employees varies from country to country in an orderly pattern. Löfgren et al. (2011) [20] studied the dynamics of quality attributes in terms of the existence of the life cycle of quality attributes .Their research proved that three life cycles of quality attributes exists, which supports the importance of the theory of attractive quality.

Conclusively it can be said that the number of papers increased however the content remained mostly the same. The number of papers which are questioning and pushing the research on the theory of attractive quality is limited.

Research Methodology

Kano Model is applied to analyze the factors affecting customer's purchase decision and prioritizing customer requirements to improve performance of the product. These are the following steps undertaken to apply Kano Model for identifying customer requirement of BEV.

(A) There are lots of factors which affect consumer satisfaction. It is necessary to distinguish the key attributes of Battery Electric Vehicle (BEV).Potential customer

requirements which included in the questionnaire were revived by collecting and summarizing lot of literature.

(B) Surveying respondents were done through questionnaires which contains a pair of questions (functional and dysfunctional). Functional questions are asked in an affirmative way and dysfunctional questions are asked in a negative way. The respondents are asked to select one from among five choices for each question. In this research we have taken a total of 10 questions pertaining to four dimensions of the Battery Electric Vehicle (BEV) which were asked to 1000 respondents. An example of a Kano model question used in the questionnaire is presented below in Table 1

Table1. Example of Functional and Dysfunctional Question

Functional Question	**Response**
1 a.Battery Longevity is more than 5 Years	1.I like it that way
	2. It must be that way
	3. I am Neutral
	4. I can live with it that way
	5. I dislike it that way
Dysfunctional Question	**Response**
1b .Battery Longevity is not more than 5 Years	1.I like it that way
	2. It must be that way
	3. I am Neutral
	4. I can live with it that way
	5. I dislike it that way

(C) When a questionnaire is to be sent to many respondents, it is important that it should be understandable specifically the Kano questionnaire, since it is unfamiliar to most of the respondents. Therefore a test run will help us in identifying confusing instructions, typographical errors or unclear wording. For that initially, we tried to predict the interviewees' response and guess the questions the customer may not understand; then, we selected some students to answer the questionnaire and the results were analyzed to find out the problems which may exist in it. Then the questions were revised and tested again. Finally we comprehend the interviewees' feedback and revise the questions if necessary.

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Table 2. Kano Evaluation Table

Customer Requirement → / ↓		**Dysfunctional**				
		Like	Must Be	Neutral	Live With	Dislike
Functional	Like	Q	A	A	A	O
	Must Be	R	I	I	I	M
	Neutral	R	I	I	I	M
	Live With	R	I	I	I	M
	Dislike	R	R	R	R	Q

Kano Evaluation Table (Table 2) has to be used to categories individual's response into different category. Different abbreviations used for different category in the evaluation table are Must-Be (M), One- Dimensional (O), Attractive (A), Reverse(R),Indifferent (I) and Questionable (Q).If the response of the respondent is "Must- Be" or Neutral" or "I can live with it" for a functional question and "I dislike it" for a dysfunctional question then the attribute would be classified as Must- Be (M). If the response of the respondent is "I like it" for a functional question and "I dislike it" for a dysfunctional question, then the requirement would be classified as One -Dimensional (O). The requirement is classified as Attractive (A), if the response of the respondent is "I like it" for a functional question and "Must- Be" or Neutral" or "I can live with it" for a dysfunctional question. If the responses of the respondent are "Must- Be" or Neutral" or "I can live with it" for a functional question and "Must- Be" or Neutral" or "I can live with it" for a dysfunctional question, then it's classified as Indifferent (I).If one attribute is not wanted by the respondent then they strongly expect the reverse, then the attribute is considered to be Reverse (R). In a unique situation, when the response of the respondent is "I like it" for both functional question as well as for dysfunctional question then it is considered to be Questionable (Q). In Kano Model, we are mainly investigating Must-Be (M), One-dimensional (O), Attractive (A) and Indifferent requirements (I).

(D) Select respondents to fill the questionnaires. This research is about identifying the attributes and categorizes them to understand the buying behaviour towards Battery Electric Vehicle (BEV) in India. So the customers working or settling in India are the ones who can afford the BEVs or be familiar with BEVs.

(E) Based on the data collected from the questionnaire, we will analyze the customer needs of BEV by means of three methods.

Method-I (Frequency-Based Attributes Category Method)

The first method which is considered to be traditional in nature is based on the mode statistics which is based on frequency of response given by the respondent. It can be presented as Grade = Max [M, O, A, I, R, Q].The frequency based method can increase the "noise level" to a point where all "requirements" are considered indifferent. For example, if 22 responses classify a function as must-be, 23 as one-dimensional, 24 as attractive, 27 as indifferent, 3 as reverse, and 1 as questionable, then the mode statistic classifies this function as indifferent even though 69 out of 100 people answering say that they need this function in one way or the other.

Method-II (Comparison-Based Method)

The second method developed from the first method to decrease the noise level to a point where all "requirements "are considered indifferent. Hence, it is suggested that if (O+A+M)> (I+R+Q), the maximum value of (O, A, M) should be adopted else the maximum value of (I, R, Q) should be adopted. This method modifies the mode statistic as Grade =Max [M, O, A], if (M + O + A) >(I + R + Q); and Max[I, R, Q] if (I + R + Q)> (M + O + A) .In some cases, when the results show same frequency for two requirements, the category having greatest impact on the product or service should be chosen following the priority order as M > O > A > I.

Method-III (Index-Based Category Method)

The third method suggests two indexes namely Satisfaction Indices and Dissatisfaction Indices which can be explained as follows:

Satisfaction Index (SI)= (A+O)/ (A+O+M+I)
Dissatisfaction Index (DI)= (M+O) / (A+O+M+I)

The Satisfaction Index ranges from 0(zero) to 1(one). When the attribute's index is closer to 1, its shows higher influence on customer satisfaction and when the value is closer to 0 it shows negligible influence on customer satisfaction. Similarly, if value of dissatisfaction index is greater, then it indicates that the impact is greater on customer dissatisfaction. Different attributes were determined based on Satisfaction and Dissatisfaction Index as described in Table3.

Table 3. Index Based Category

If Satisfaction Index is	If Dissatisfaction Index is	Attribute
< 0.5	< 0.5	Indifferent
< 0.5	≥ 0.5	Must-be
≥ 0.5	≥ 0.5	One-dimensional
≥ 0.5	< 0.5	Attractive

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By using the methodology, the analysis was done to find out the customer needs of BEV. As one new product with immature technology, the attributes affecting the customers' purchasing decision of BEV are quite different from the traditional motor vehicles. Therefore, it is necessary to gain insight into the attributes with respect to the customer satisfaction and firm's capacity. Finally 10 attributes of BEV are identified, by summarizing a large number of related literature and taking into account of the environment and policy issues in India as shown in Table 4.

Table 4. BEV Attribute

Attributes	Description of BEV Attributes	Benefits provided to Customers
a1	Battery Longevity is more than 5 Years	Beneficial
a2	Comparatively Low Price	Beneficial
a3	Government Provide Subsidy	Beneficial
a4	Maintenance Cost is low	Beneficial
a5	Availability of sufficient Charging Station	Convenient
a6	Battery charging completes in 15 minutes	Convenient
a7	Driving range exceeds 120km	Convenient
a8	Appearance of the vehicle is attractive	Cheerful
a9	Availability of presales consulting services	Cheerful
a10	Maximum speed is over 120km/h	Fast

The Kano questionnaire is comprised of two parts: Part A consists of the demographic information of respondents, e.g., gender and education; and Part B consists of 10 pairs of questions with respect to the 10 attributes in Table 4. Taking attribute *a1* "Battery Longevity" as an example, the questions are designed as shown in Table 1. The respondents who have cars or want to buy new cars in India were asked to provide their answers with respect to the 10 pairs of questions via face-to-face survey.

With the Kano evaluation data collected, we now use the three Kano methods to process and analyze the customer needs of BEV in India. With the principle of frequency-based, comparison-based and indexed –based the classification of the attributes can be obtained, as shown in Columns 3,4and 5 of Table 5.

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Table 5. Kano Categorization of BEV Attributes

Attributes	Description of BEV Attributes	Frequency-Based	Comparison-Based	Analysis-Based	Category
a1	Battery Longevity is more than 5 Years	M	M	M	M
a2	Comparatively Low Price	I	A	A	A
a3	Government Provide Subsidy	A	A	A	A
a4	Maintenance Cost is low	O	O	O	O
a5	Availability of sufficient Charging Station	M	M	M	M
a6	Battery charging completes in 15 minutes	A	A	A	A
a7	Driving range exceeds 120km	M	M	M	M
a8	Appearance of the vehicle is attractive	I	A	A	A
a9	Availability of presales consulting services	I	M	I	I
a10	Maximum speed is over 120km/h	M	M	M	M

It is clearly seen from Table 5 that with the same data set, different results can be obtained by means of the three Kano methods. The classification of attributes of all the three methods is very similar with each other. The final categorizations of the BEV attributes are obtained as shown in Column 6 of Table 5, by applying the "majority rule". After analyzing the result, it's found that the four attributes like "Battery Longevity is more than 5 Years (a1)","Availability of sufficient Charging Station (a5)", "Driving range exceeds 120km (a7)", and "Maximum speed is over 120km/h" (a10) are categorized as must-be type attributes. It indicates that, the customers will be very dissatisfied if they experience the absence of these attributes; however, presence these attributes cannot increase customer satisfaction. Let us take the case of "Availability of sufficient Charging Station" as an attribute. As technology is new, the customers are worry about the charging stations of BEV. The customers will be very much dissatisfied if there are fewer charging stations. In this way, "Availability of sufficient Charging Station" becomes an essential requirement for the customers to use the BEV.

The attribute "Maintenance Cost is low (a4)" is viewed as one-dimensional quality. It means the customers will be satisfied with this attribute; and the customers will be dissatisfied without this attribute. Lower maintenance cost will enhance customer satisfaction and higher maintenance cost will give rise to customer dissatisfaction. From the result it's evident that four attributes are falling under attractive quality namely "Comparatively Low Price (a2)", "Government Provide Subsidy (a3)", "Battery charging completes in 15 minutes (a6)", and "Appearance of the vehicle

is attractive (a8)". We can conclude that "high price" is insignificant and has minimal impact on customer dissatisfaction of BEV. Customers who are intended to buy BEV are convinced that the prices of BEV are more expensive than the one of traditional motor vehicles; due to the immature technology and lack of large-scale production. So the high price of the BEV is not going to create customer dissatisfaction. However, lower price will considerably increase customer satisfaction. As for the government subsidy, the India government with NITI Aayog now decided to provide subsidy to customers who buy BEV. This policy will greatly promote the adoption of BEV.

The attributes "Availability of presales consulting services (a9)" categorized as indifferent quality. This indicates that the companies need not to pay much attention to this attribute at present.

According to the strategic rule M >O >A>I, firms offering BEV as well as the government have to fulfill all the must-be requirements, otherwise customers will be very disappointed with the BEV. They should make extraordinary improvement of one-dimensional qualities as compared to traditional motor vehicles to make the BEV more competitive. Finally, the customers will be delighted if the attractive requirements are fulfilled.

Conclusion

There are many impediments to the wide adoption of BEV in practice as the technology is in very nascent stage. It is vital to identify and classify the customer needs of BEV so as to help government and firms to pay attention to the attributes which affects customers' purchasing decision of BEV. Customer need analysis for the BEV based on Kano model is explored to promote the adoption of BEV in India in this study. A total of 10 BEV's attributes are firstly determined by summarizing the previous researches and combining current advantages of policy. It takes into the customer's psychology account and combines the frequency-based, comparison-based and index-based methods to categorize the BEV attributes. The attributes are classified broadly in to 4 category i.e. Must-be quality (M), One-dimensional quality (O), Attractive quality (A) and Indifferent quality (I). As per the strategic rule M > O > A > I, the priorities of efforts towards promotion and adoption of BEV is identified, i.e., government as well as the vehicle firms have to fulfill all the must-be requirements. They should make prodigious improvement of one-dimensional qualities to make the BEV competitive to the traditional motor vehicles. Finally, the customers will be overwhelmed if the attractive requirements are fulfilled.

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