Integration of Conjoint Analysis and Environmentally Conscious Quality Function Deployment for Design Development of Battery Electric Vehicle in Indonesia

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Abstract

The increase in carbon emissions by the transportation sector is correlated with the rise in the number of vehicles in Indonesia, especially vehicles with internal combustion engines which reaches at least 30% of the total national carbon emissions. Carbon emissions cause environmental damage, prompting the Indonesian government to implement a carbon emission policy on ICE vehicles, and the adoption of electric-based vehicle. However, the customers' adoption rate is still limited, partly due to the limited choice of electric vehicles products in Indonesia and unit prices, which are still relatively expensive. This paper intends to explore the design of electric vehicles by paying attention to customer needs to obtain product designs that are most in-demand and most likely to be realized by the related industry. For this purpose, the integration of conjoint analysis (based on full combination model) and environmentally conscious quality function deployment (QFD) methods is carried out, helpful in connecting customer aspects with technical aspects in the automotive industry. The research was conducted by exploring nine attributes and 30 levels of product design variations covering performance, technology, and service aspects of electric vehicle such as maximum power and torque; maximum range; vehicle model; battery capacity; battery charging speed; expected battery life; technology features and vehicle price. 32 design variation obtained which combining nine attributes and 30 product design level. Through environmentally conscious quality function deployment (ECQFD) method, the product design obtained is realized as a production strategy to obtain an electric vehicle design that best suits customers' preferences.

Keywords
Emission, Electric Vehicle, Conjoint Analysis, ECQFD, Design

1. Introduction
Climate change and carbon emissions have become the most worrying environmental problems in recent decades. Various policies and strategies were taken to address these problems, considering how severe the impacts have been. The consequence is changing the trend of foil-driven motorized vehicles to electric vehicles. Manufacturers, governments, and society consider that using electric vehicles can significantly reduce carbon emissions worldwide. As one of the largest automotive markets in Asia, Indonesia occupies an important position in reducing carbon emissions where the number of motorized vehicles is correlated with the amount of carbon produced. In Indonesia, carbon emissions are dominated by the transportation sector, which accounts for 30% (or more than 120,000 GG) of national annual carbon emissions and is estimated to grow by 7.17% annually (Institute for Essential Services Reform, 2020). This prediction is even more worrying considering the rapid growth in the number of motorized vehicles in Indonesia, primarily passenger vehicles with internal combustion engines. Based on the report, in 2020, there were at least 15,797,746 units of ICE passenger vehicles (GAIKINDO 2021).

The adoption of electric vehicles in the world is nothing new. However, the rate of BEV adoption in Indonesia tends to be low compared to other countries, such as the United States of America, which, in 2021, will adopt 434,879 electric vehicles from 1,236,429 new vehicles that year (Jin 2022). At least 400,000 electric vehicles will be used in the United Kingdom by 2021 (Powell, 2022). In comparison, in the same year, the public only adopted 488 electric vehicles (GAIKINDO, 2021). It must be acknowledged that various factors influence people's interest in electric vehicles, Indonesia, in particular, the price difference between conventional vehicles and electric vehicles is still high. Moreover, Indonesians still think that using electric vehicles does not have a practical economic value. This thought is quite reasonable if you look at the fact that the cost of maintaining electric vehicles, especially batteries, is at least

40% of the purchase price of the electric vehicles. Moreover, electric vehicles in Indonesia are classified as new technology, which means that the supporting facilities are still inadequate. From a design perspective, electric vehicles in Indonesia are still not as varied as shown in the ICE vehicles market. The limitations of the available models strongly influence the level of adoption of electric vehicles in Indonesia. The limited model availability indicates that the electric vehicles products circulating in Indonesia until now still do not fully reflect the wishes of consumers, so there needs to be an effort to connect the two.

The importance of adopting electric vehicles, especially concerning environmental sustainability issues and the sustainability of the transportation system, the acceptance factor at the individual level must be taken into account. Electric vehicles adoption is closely related to consumer choice, especially in individual decision-making. In this argument, the product that best reflects consumer desires is highly likely to be adopted. Based on various studies that have been carried out, consumers make several considerations to adopt an electric vehicle, such as vehicles performance, price, and design to the level of efficiency of the electric vehicles. The performance of an electric vehicles can be represented by several aspects such as maximum power and torque from the vehicles, battery capacity up to the maximum distance that can be traveled in one battery charge, and battery charging time. In Indonesia, a factor plays a vital role in the adoption of electric vehicles, namely vehicles design. In this case, the design is described as an electric vehicles model (MPV, SUV, or sedan).

Several studies have been conducted to determine what factors influence the adoption of electric vehicles. Wu et al. (2019) analyze the effect of public acceptance of autonomous electric vehicles using the Technology Acceptance Model (TAM) method, which shows environmental factors, perceived usefulness, and perceptions of 'ease of use,' which are strongly associated with interest in electric vehicles adoption. Outside of the study, in general, two views are considered influential in consumers' adoption of electric vehicles. First, emphasis is on instrumental factors or functional attributes such as reliability, battery charging time, maximum speed, purchase price, maximum distance in a single charge, and operational or maintenance costs (Egbue and Long 2012; Graham-Rowe et al. 2012; Schuitema et al. 2012). al. 2013; Krupa et al. 2014). Second, the emphasis on factors related to environmental issues and awareness strongly influences the adoption process (Rahmani and Loureiro 2018; Chen et al. 2021). With all its consumer profiles, Indonesia tends to fall into the first category since environmental awareness, and vehicle sustainability issues are not the main issues to consider in making a purchase (GAIKINDO 2021), especially purchases at low prices such as electric vehicles. In previous studies, none of these have linked consumer interests or preferences with how the product should be realized. Finally, a study was conducted to link consumer preferences and product design of electric vehicles with more consideration of environmental aspects through the environmentally conscious quality function deployment (QFD) method with voice of customers obtained through conjoint analysis.

1.1 Objectives
The main objective of this study is to determine the electric vehicles design that best represents consumer preferences. Those preferences were compiled from a combination of nine attributes and 30 levels of variation. Best representing combination then translated into a house of quality so that the automotive industry has a picture that is not only limited to consumer preferences but also about how products must be executed.

2. Literature Review
Quality function deployment is strongly associated with the contribution made by Dr. Yoji Akao. QFD is widely used to translate consumer desires into appropriate technical requirements in product development (Sullivan 1986). QFD will be very useful in developing quality and consumer-friendly products. QFD emphasizes quality during the product design process to minimize deficiencies in the early phases of design development by lowering costs and increasing productivity. ECQFD was introduced as another variation of QFD, which considers environmental awareness in the product design process. Masui et al. (2003) used a method similar to ECQFD called quality function deployment of environment for environmentally conscious design, which was limited to the early phases of product design. Rathod and Puranik (2017) use ECQFD for product development by paying attention to environmental aspects so that environmentally conscious products can be obtained. The study said that ECQFD phases I and II in this method are strongly related to part identification and product quality improvement with product output that has environmental awareness. However, ECQFD phases III and IV focus on evaluating the suitability of improvised designs to environmental requirements. The study proves that ECQFD has a level of application on an industrial scale as a research regime. Rathod, Vinodh, and Madhyasta (2011) integrated the ECQFD method with life cycle assessment (LCA) in electric vehicles manufacturing organizations to realize sustainable products. Through this research, it is

proven that ECQFD has the flexibility to be integrated with other methods for different purposes. However, the combination of ECQFD and LCA in the initial development is still considered inappropriate, especially in developing markets such as Indonesia, which requires a strategy to attract consumer interest in a product.
Moreover, electric vehicles research topics have focused on studying the acceptance and prospects of electric vehicles in the future (Liao et al. 2017; Mahmoudzadeh Andwari et al. 2017; Khazaei 2019; Chen et al. 2021; Febransyah 2021) and studies those specified on electric vehicle design is still limited. So conjoint analysis was chosen as a combination of the ECQFD method. The integration of conjoint analysis with ECQFD in electric vehicles design has not been found. It is essential to do this so that the designed electric vehicles can be a solution to environmental problems. Next, the thing that must be avoided is that electric vehicles can be a source of other environmental problems, so it is necessary to realize electric vehicle that accommodates environmentally conscious design.

3. Methods

3.1 Conjoint Analysis

Conjoint Analysis (CA) is a tool or instrument used to quantify psychological components in the form of utility. CA can be used to understand how consumers make decisions with attribute contributions and levels. It can be said that the purpose of CA is to obtain the best response from consumers to the combination of attributes and levels in a product. CA is also used to determine how consumers are willing to sacrifice attributes and the level of one attribute to another. The success of conjoint analysis requires that the research accurately define all attributes that have a negative and positive impact on consumer tastes and apply appropriate models of how to combine individual attribute values into an overall evaluation of the object.

The results of the conjoint analysis can be used to estimate the utility of each level in each attribute, determining the total utility of each stimulus so that it can be compared with other stimuli to predict consumer choice. The essential basis of the conjoint analysis experiment is the combination design that the respondent will evaluate. The number of combinations is closely related to the number of attributes. Two limitations that can be used to consider the number of attributes in research: first, adding more attributes will increase the minimum number of combinations in the conjoint design; consequently, the number of observations must exceed the number of estimated coefficients; second, the number of combinations must be increased when the complex relationship model is deployed. The following formula can evaluate the minimum number of combinations that each respondent must evaluate:

Minimum number of combinations = Total Number of Levels across attributes – number of attributes + 1

In this study, the combination of levels and attributes is obtained through orthogonal design features in statistical software. In general, there are several variations of the CA method: The entire combination method is the most popular because of its ability to reduce the number of comparisons through a fractional factorial design. In this method, each combination is explained separately by using a combination card. This approach gives rise to fewer but more complex assessments, and the assessment can be either a rating or a grade. The advantage of this method is that a more realistic design description is guaranteed. Design description contains a combination of levels for each attribute, the explicit description between all attributes, and the correlations between attributes. The pairwise combination method is a method that involves the comparison of two combinations using a rating scale to indicate the strength of preference for one combination over the other. The distinguishing characteristic of the pairwise combination method is that the combination does not contain all the attributes. If the number of attributes is large enough, the researcher should be careful not to adopt this method by describing too few attributes; The trade-off method compares two attributes at a time by comparing all level combinations. This method is relatively easy for respondents to understand and implement and avoids information overload by presenting only two attributes simultaneously. This method also has limitations. Namely, it cannot use fractional factorial designs to reduce the number of comparisons required.

3.2 Environmentally Conscious Quality Function Deployment (ECQFD)

The research was conducted by adopting the QFD model developed by Yoji Akao, where the voice of the customer was obtained from the conjoint analysis method. Design improvement targets are identified through the quality house in phases I and II. In general, ECQFD does not have a significant difference from QFD, which emphasizes improving quality in the design process to minimize product defects, reduce production costs and increase productivity. The two approaches were chosen to compare the most likely to be applied by the automotive industry players, especially regarding environmentally friendly and sustainable practices.

Quality function deployment (QFD) can be used in production processes that tend to be complex and require professional expertise to develop a house of quality (HoQ). ECQFD is a condensation of environmental aspects with QFD, which emphasizes the amount of material used, and material toxicity to environmentally friendly materials.

QFD phase 1 explains how QFD relates the VOC to the design aspect to be optimized. The customer weighting, in this case, is the utility value obtained through conjoint analysis. The main output in this process is the engineering matrix which contains the weighting of each product related to the design aspects and the technical response in a design process. There are four general phases in QFD, namely the product planning phase, part planning phase, process planning phase, and production planning.

Early in the QFD process, the design team must listen to the Voice of Customer (VoC) to identify consumer needs and interests. VoC must represent consumer needs obtained from the results of interviews or surveys. The results of the VoC show the value of products, services, and processes and convert them into a metric table of customer needs. Furthermore, the technical response contains responses related to product development of a technical nature, such as material reduction, selection of alternative material for feature reduction, and others.

3.3 Integrasi Conjoint Analysis dan ECQFD

The integration of ECQFD and conjoint analysis has previously been carried out by Atanu (2005), who provides recommendations for the simultaneous use of conjoint analysis and QFD. This recommendation is given because integrating the two methods can be used to answer conditions close to the actual case in a company that requires an approach to the attribute level and pricing and market share determination. They tried to apply conjoint analysis and ECQFD to determine the attribute level of a commercial vehicle by considering the cost of product development and the cost of increasing technical response. An analysis of 6 attributes of a commercial vehicle was carried out, where the attributes were determined based on the survey results.

Li Baishu (2011) performs QFD integration and conjoint analysis by considering market segmentation. Segment formation is done based on the variable of interest. The object of observation is a vehicle that considers four-vehicles attributes, so 36 combinations are formed. The drawback of this research is that the product level utility HoQ process is not considered, so the formed technical response cannot answer the complete technical response for product combinations in each segment and as a whole.

The model used in this study refers to the model developed by Irawati et al. (2014). In this study, Irawati developed a model that integrates conjoint analysis with QFD to analyze consumer preferences for an office equipment product, with the ultimate goal of knowing consumers' willingness to pay for particular attributes and levels in a product.

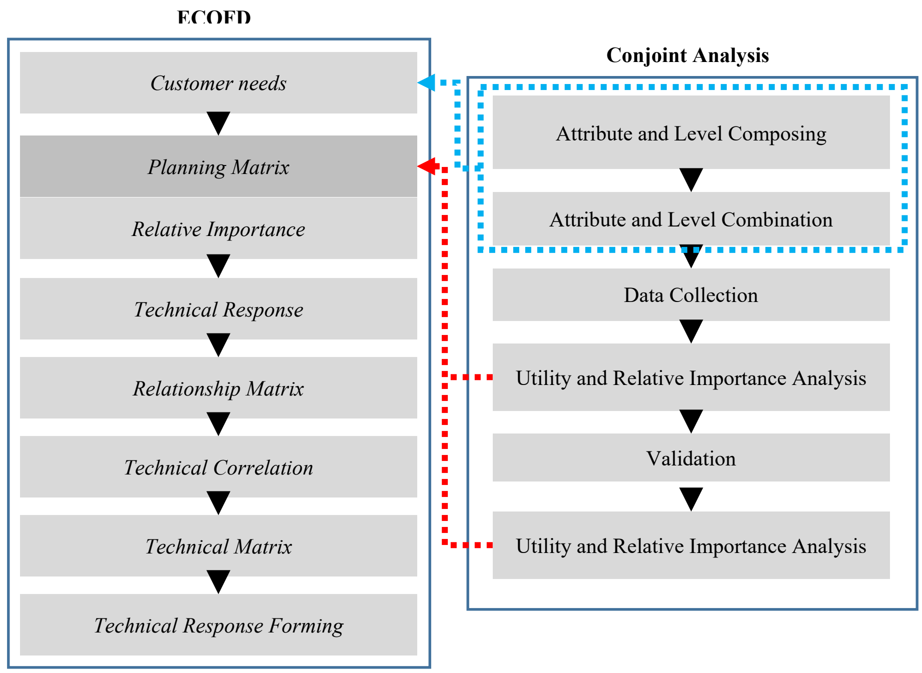

Figure 1. Conjoint Analysis and QFD Integration Base Model

4. Data Collection

The research was conducted by compiling the attributes and levels of each attribute. The nine selected attributes represent the performance and design aspects of the electric vehicles that will be submitted for the survey phase to consumers, namely: the attributes of an electric vehicles model consisting of three variations of levels (MPV, SUV, and Sedan); maximum range in kilometers consisting of four variations of levels (150, 250, 350, 450 km); maximum battery capacity in kWh with four varying levels (40-50, 51-60, 61-70, and 71-80 kWh); DC/AC battery charging speed in minutes/hour with three varying levels (40-50 minutes/5 hours, 50-60 minutes/6 hours, 60-70 minutes/7 hours), maximum power BEV with three levels variation (200 hp , 250 hp, and 300 hp), maximum torque with three varying levels (250 Nm, 350 Nm and 450 Nm), expected battery life with three varying levels (10 years/160,000 km, 15 years/240,000 km and 20 years/ 320,000 km), in terms of technology or features, there are two variations, namely the presence and absence of ADAS (Advanced Driving Assistance System) which summarizes technological features such as adaptive cruise control, line keeping assist, collision warning and others. Then, in terms of the price to be paid, there are five variations of levels (500, 600, 700, 800, and 900 million rupiahs). A summary of attribute and level variations is listed in table 1.

Tabel 1. Attributes and levels in conjoint analysis

Aspects	**Attributes**	**Level**				
		1	2	3	4	5
Design	Model	MPV	SUV	Sedan	-	-
Efficiency	Max. Range (Km)	150	250	350	450	-
	Max. Battery Capacity (kWh)	40-50	51-60	61-70	71-80	-
	Charging Time DC/AC (minutes/hours)	40-50/5	50-60/6	60-70/7	-	-

Performance	Max. Torque (hp)	200	250	300	-	-
	Max. Torque (Nm)	250	350	450	-	-
Reliability	Expected Battery Life (years/km)	10/160.000	15/240.000	20/320.000	-	-
Technology	ADAS	present	absence	-	-	-
Economy	Price (mil. rupiah)	500	600	700	800	900

Based on the table above, the stimuli card was compiled as the basis for compiling a questionnaire for data collection. Stimuli cards were arranged using the combination conjoint analysis method and reduced by fractional factorial design to obtain 32 stimuli cards which would then be presented to the respondents. The next phase is a survey of consumers. The survey was conducted on 500 respondents with data processing using conjoint analysis. The validity test is carried out by evaluating the goodness of fit on the correlation value formed. The goodness of fit analysis aims to test the consistency of respondents in filling out the questionnaire. The measurement of goodness of fit can be seen from the correlation values of Pearson's R and Kendall's Tau. Pearson's R correlation is used to calculate data with a rating scale, while Kendall's Tau calculates data with a ranking scale. In order to maintain the accuracy and consistency of respondents in filling out the questionnaires, the minimum value for the significance value of the p-value is <0.05. If the correlation value is less than 0.05, it is known that the model is accurate, and the data is worthy of further analysis. After the conjoint analysis results are obtained, the next step is to integrate the ECQFD method. The determination of environmentally friendly criteria in the HoQ ECQFD is based on the Minister of Environment and Forestry Regulation No. P.5/MENLHK/SETJEN/Kum.1/2/2019 concerning Procedures for Application of Environmentally Friendly Labels for Procurement of Environmentally Friendly Goods and Services with environmental criteria regulated in Article 7 paragraph (1): selection of raw materials, supporting materials which are non-toxic and hazardous, the type of energy for production and/or utilization and post-utilization of the product. In addition, referring to these regulations, the criteria are also adjusted to the research of Rathod and Puranik (Rathod and Puranik 2014), which is also an overview of the criteria set by the local government in preserving the environment.

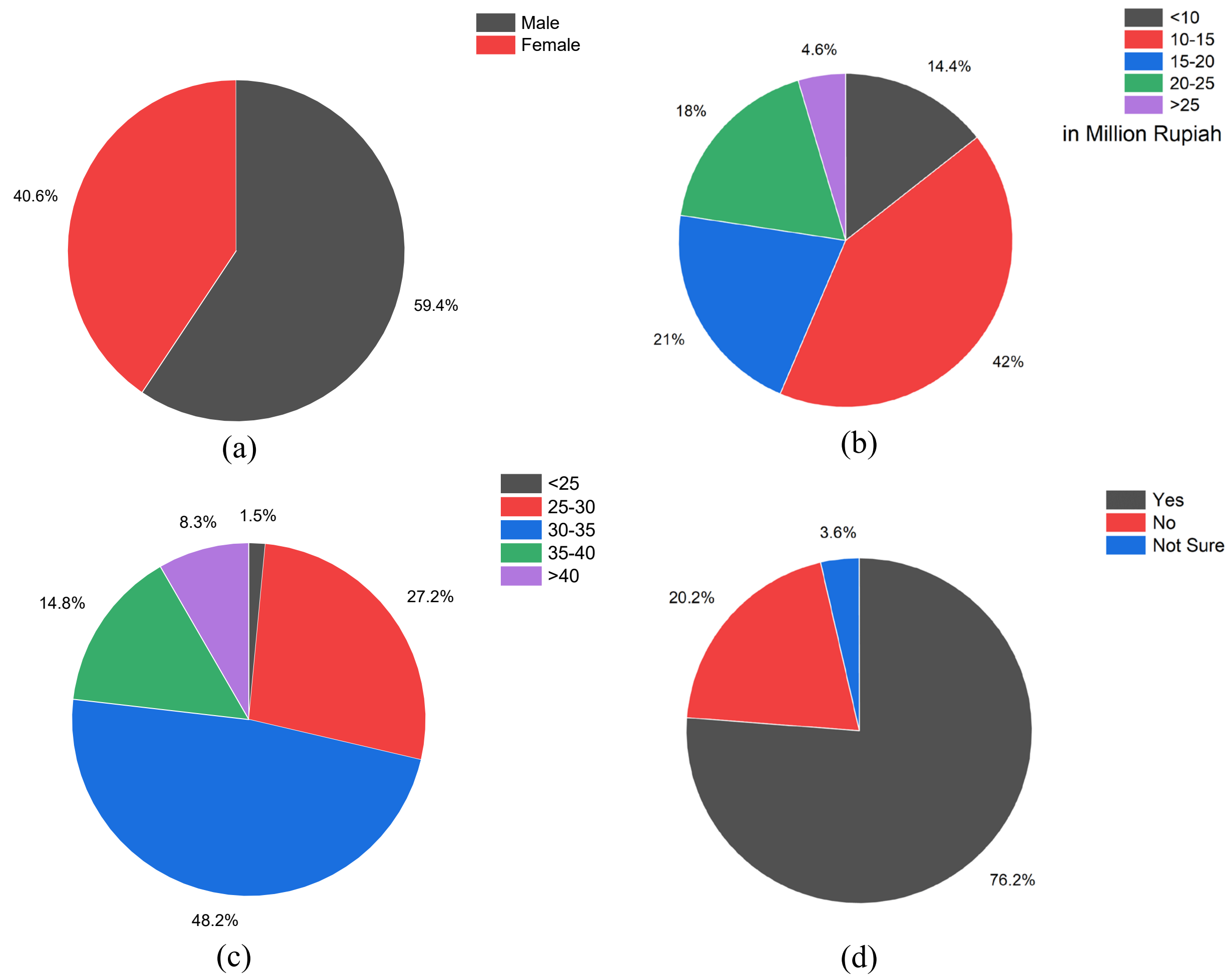

Figure 2. Respondent Profile

Figure 2. shows the respondent's profile by gender (a), monthly income (b), respondent age (c), and their intention to buy BEV in the future (d). The gender of the respondents is considered sufficient to represent the population in Indonesia, of which 50.58% are male, and 49.42% are female. Based on Figure 1, it is known that 48.2% of respondents are from the age group of 30-35 years, and 42% of respondents are from the monthly income group of 10-15 million rupiahs (690 USD-1040 USD). Figure 1 (d) shows that at least 76.2% of respondents have the intention to adopt BEV in the future. Furthermore, respondents will be asked to assess the stimuli vehicles, which contains a combination of attributes and a predetermined BEV level on a scale of 1-9 (1 indicating dislike to 9 indicating liking). The results obtained are then processed using the conjoint analysis method so that these results are then discussed with the automotive company to prepare the HoQ (ECQFD).

5. Results and Discussion

5.1 Customers' Electric Vehicle Utility

Based on the data obtained from the respondents, the goodness of fit evaluation was then caried out on the correlation value formed. This evaluation aims to assess the consistency of respondents in filling out the questionnaire. The goodness of fit measurement can be assessed by the correlation value of Pearson's R and Kendall's Tau. Pearson's R correlation is used to calculate data with a rating scale, while Kendall's Tau calculates data with a ranking scale. The data obtained in this study is a rating scale so that the evaluation is carried out with a Pearson's R-value. A minimum limit must be met, and the significance value of the p-value must be <0.05. Suppose the significance value is within the specified range or less than 0.05. In that case, it can be judged that the questionnaire model provided is accurate and that the data obtained is suitable for further analysis. Pearson's R and Kendall's Tau values in this study are summarized in table 2.

Table 2. Correlations value of the model

Correlations [a]		
	Value	Sig.
Pearson's R	.975	.000
Kendall's tau	.891	.000

[a] Correlations between observed and estimated preferences

The significant value of each criterion in Table 2 stated that the multiple linear regression model used has an acceptable level of accuracy and is then analyzed using the conjoint analysis method. Based on the analysis, the utility values of each level and attribute are presented in table 3.

Table 3. Utility value of each attribute and level in testing

Attribute	Level	Utility Estimate	Std. Error
Model	MPV	.067	.043
	SUV	.052	.051
	Sedan	-.119	.051
Technology Feature	with ADAS	.087	.032
	without ADAS	-.087	.032
Maximum Range	150 km	.363	.029
	250 km	.726	.058
	350 km	1.088	.087
	450 km	1.451	.116
Max. Battery Capacity	40-50 kWh	-.040	.029
	51-60 kWh	-.080	.058
	61-70 kWh	-.120	.087
	71-80 kWh	-.160	.116
Charging Time DC/AC	40-50 minutes/5 hours	-.061	.039
	50-60 minutes/6 hours	-.122	.078
	60-70 minutes/7 hours	-.184	.117
Max. Power	200 hp	.006	.039
	250 hp	.012	.078
	300 hp	.018	.117
Max. Torque	250 Nm	-.055	.039
	350 Nm	-.110	.078

Attribute	Level	Utility Estimate	Std. Error
	450 Nm	-.165	.117
Battery Expected Life	10 years/160.000 km	.240	.039
	15 years/240.000 km	.481	.078
	20 years/320.000 km	.721	.117
Price	500 million rupiah	-.339	.025
	600 million rupiah	-.679	.049
	700 million rupiah	-1.018	.074
	800 million rupiah	-1.358	.098
	900 million rupiah	-1.697	.123
Constant		5.614	.186

Based on table 3, it is known that each attribute consisting of two levels has the same utility value with different signs (positive and negative). The more positive value in the utility value describes consumer interest in specific attributes or levels because 1 indicates the least desirable combination while 9 indicates the most desirable combination. Based on the analysis conducted, the importance value is obtained as presented in table 4 below. Utility Value of Each Attribute and Level in Testing

Table 4. Importance Values

Importance Values	
Model	12.984
Technology Feature	6.321
Max. Range	17.637
Max. Battery Capacity	7.119
Charging Time DC/AC	8.312
Max. Power	6.699
Max. Torque	6.243
Expected Battery Life	10.842
Price	23.843

Based on the two tables above, it is known that consumers in Indonesia consider that the economic aspect represented by the price attribute is the most important in adopting BEV. Consumers want BEV with a price of around 500 million rupiahs in that attribute. Maximum range still occupies the highest priority level for consumers with an expected range of 450 km on a single full charge; while the third priority is occupied by the attributes of the model with the desired BEV model, namely the MPV (Multi-purpose vehicle) model which is actually in line with the most popular ICE vehicles model in Indonesia, namely the MPV (GAIKINDO, 2022); Problems related to BEV batteries are still one of the concerns of consumers since the cost of replacing BEV batteries can reach 30-40% of the price of the vehicles they pay so that the expectation of battery life shows the rationality of consumers in adopting BEV with the expectation of battery life ranging from 20 years/320,000 km, this battery life expectancy is a quantity that describes the battery's performance in terms of storage and charging capabilities; the following priority attribute is still related to the battery, namely the speed of charging the battery with a charging duration of 40-50 minutes/5 hours; while the maximum battery capacity of interest is at a capacity of 40-50 kWh; then the bottom three attributes are occupied in a row by maximum power, technology features presence/absence of ADAS; and maximum torque around 250 Nm.

The importance value obtained in this analysis (table 4) is then integrated with the ECQFD method to determine the technical response from an environmental perspective and part selection with the developed perspective. The obtained importance value becomes a priority reference in the BEV design that will be developed primarily in the Indonesian BEV market because this value describes the voice of consumers about the BEV they want.

5.2 Environmentally Conscious Quality Function Deployment on Electric Vehicle

The important value obtained from the previous analysis is integration into the ECQFD (Environmentally Conscious Quality Function Deployment) method. When referring to pure ECQFD, the voice of the customer that is used revolves around environmental aspects such as minimalist materials, ease of reuse, and post-use handling (as waste). When it comes to integration with conjoint analysis, the voice of the customer is replaced with attributes with importance value obtained. QFD and all of its variants have elements that can describe consumer needs. However, the accuracy of the description can still be questioned because it is only limited to assumptions and approaches taken by product designers so that the existence of conjoint analysis can complete the description in more detail (Irawati et al. 2014; Vinodh and Manjunatheshwara 2017). This section will discuss the integration of conjoint analysis in ECQFD, especially in developing electric vehicles designs/products that reflect the needs of consumers in Indonesia.

Electric vehicles strongly correlate with environmental sustainability (carbon emissions). In this study, the VoC used is not the same as the study conducted by Rathod et al. (2011), namely: easy to drive; fully automatic; tubeless tires; 80 km range on a single charge; easy charging while the VoC in this study refers to the results of the analysis (table 4). The technical response in the house of quality refers to the regulation of the Minister of the Environment and Forestry No. P.5/MENLHK/SETJEN/Kum.1/2/2019 concerning Procedures for Application of Environmentally Friendly Labels for Procurement of Environmentally Friendly Goods and Services with environmental criteria regulated in Article 7 paragraph (1): selection of raw materials, supporting materials which are non-toxic and hazardous, types of energy for production and/or utilization and post-utilization of products combined with points in the engineering matrix as in the study conducted by Rathod, Vinodh and Madhyasta (2011). The weighting is carried out qualitatively, which generally describes the relationship between two items: strong, moderate, and weak, which in this study are represented by weights of 9, 3, and 1.

HoQ phase I, shown in table 5, contains the relationship formed between the voice of the consumer and the technical response that has been adapted to environmental items as described above. There are nine technical responses selected in this study, namely: weight, volume, number of parts, physical lifetime, biodegradability, amount of energy, and toxicity. Electric vehicle models such as the MPV have relatively larger dimensions when compared to other models such as SUVs and sedans. In this regard, they have a strong correlation with the weight and volume of the vehicle, moderate with the number of parts used. It requires more energy in production than other models because it correlates with the vehicle's total weight (Sato and Nakata 2020). The maximum range in this phase correlates with the total weight, where the minimum weight will increase the maximum range of the vehicle and the completeness of the battery management system, which is represented by the number of parts. Attributes directly related to batteries, such as maximum battery capacity, battery charging, and battery life expectancy, have a strong relationship with battery toxicity. Those strong relations are present because of the materials used to manufacture the battery, i.e., lithium.
Furthermore, conventional materials such as lithium, Pb-acid, NiMH, and others are still used. Components and technical responses were given a correlation value of 9 for a strong correlation, 3 for a moderate correlation, and 1 for a weak correlation. No value means that the components are considered to have no correlation value.

Based on the correlation value multiplied by the relative weight of the voice of customers, which is finally added up, a rating of each technical response is obtained. Based on those ratings, it adjusted to the points of environmental awareness. This value becomes the basis for entering the next HoQ phase, phase II. HoQ phase II contains the selection of product components based on the selection of HoQ phase I.

Table 5. ECQFD Phase I for An Electric Vehicle

Relative Weight (%)	Customer Importance		Voice of Customer	Weight	Volume	Number of Parts	Number of type material	Physical lifetime	Rate of Recycled materials	Biodegradability	Amount of Energy	Toxicity
0.811	8	Design	Model: MPV	9	3	3					3	
3.284	5	Efficiency	Range: 450 km	9	1	3	3		1		3	9
3.969	2		Battery capacity: 40-50 kWh	9	3	3	3			1	9	9
2.276	6		Charging: 40-50 minutes/5 hours			3	3	1	1	1	3	3
0.129	9	Performance	Max. Power: 300 hp	9	9	3		1		1	1	
1.371	7		Max. Torque: 250 Nm	9	9	3		1		1	3	
3.698	4	Reliability	Expected battery life: 20 years/320.000 km					9		1		3
80.579	1	Technology	Equipped with ADAS			9	9	1	3	1		
3.883	3	Economy	Price: 500 million rupiah	1	1	1	1	1	3			
			Max Relationship	46	26	28	19	14	8	6	22	24
			Technical Response rating	89.959	35.007	764.614	757.681	121.52	258.946	92.022	59.076	83.199
			Relative Weight (%)	0.040	0.015	0.338	0.335	0.054	0.114	0.041	0.026	0.037
			Rank	6	9	1	2	4	3	5	8	7

Table 6. ECQFD Phase II for An Electric Vehicle

HoQ1 Relative Weight	Voice of Customer	AC Motor	AC Motor Controller	Gear Box	Battery Pack	Battery Controler	Safety System	Battery Safety System	Vehicle Chasis	Vehicle Frame
0.054	Weight	3	1	3	9	1	3	1	9	3
0.114	Volume	3	1	3	3	1	3	1	3	3
0.338	Number of Parts	3	1	3	3	3	3	9	1	1
0.026	Number of type material	1	3	3	1	3	1	1		
0.037	Physical lifetime	3	1	1	3	3	3	1		
0.000	Rate of Recycled materials	3		3					9	9
0.000	Biodegradability				1			1		
0.000	Amount of Energy	3	1	3	3	1	3	1	3	3
0.000	Toxicity	1			9				1	1
	Max Relationship	20	8	19	32	12	16	15	26	20
	Overall rating	2.13448	1.47798	2.66017	2.3646	2.26146	1.75427	3.55292	1.88778	1.64917
	Relative Weight	0.108	0.075	0.135	0.120	0.115	0.089	0.180	0.096	0.084
	Rank	5	9	2	3	4	7	1	6	8

Based on the ECQFD Phase II carried out, the priority of part selection is obtained, which will later describe consumer desires while reflecting environmentally friendly products (Table 5 and Table 6). Referring to the results shown in Table 6 above, the priority of part selection for the design is in the selection of the battery safety system; gearbox; battery packs; battery controllers; AC motors; vehicle chassis; safety systems; vehicle frames; and AC motor controllers. Product improvement targets carried out in phases III and IV can only be seen if the product model/design has been realized and feedback is obtained from the realized product. As an alternative, it can be done by specifying several product options that meet the criteria determined based on ECQFD Phase I and Phase II. The improvement target can be chosen from the priority of the selection of parts obtained from table 6 above. In this case, the improvement target chosen can be improvising the battery safety system, gearbox, battery packs; AC motors; vehicle chassis; safety system so on, until the last one is the AC motor controller.

5.3 Proposed Improvements

In tables 5 & 6, several things must be considered in designing an electric vehicle that reflects consumer desires based on table 3. The intended design target can be seen in the voice of customer section in table 5. Technical response in table 5 can be adjusted to each situation -respective manufacturers refer to local government regulations. The types of improvisations that can be made refer to the technical response in table 5. For example, if the improvisation chosen is a vehicle chassis, it is then related to the overall weight of the chassis, materials that can be recycled, then the volume and amount of energy required for chassis production. If battery improvisation is chosen, then what can be done refers to the overall weight of the battery, toxicity, volume, number of parts, physical lifetime, rate of recycled materials, and others. These references can finally be used as a benchmark to determine the type of material used as a battery pack. The preparation of the parts in table 6 is carried out with the help of practitioners of the electric vehicles industry in Indonesia, which can then be developed and adapted to certain types of parts. In this process, more contributions from electric vehicles industry practitioners are needed to realize more accurate results.

6. Conclusion

Based on the research conducted, several conclusions were obtained, namely:

1. Application of conjoint analysis can be used as input in the voice of consumer section in the ECQFD, and the relative importance of the results of the conjoint analysis can be used as input for the planning matrix stage;
2. Conjoint analysis can be an instrument that bridges the interests of consumers and industry, especially in the design of electric vehicles;
3. Electric vehicles that best represents consumer desires has the following specifications: MPV model; maximum range of 450 km; maximum battery capacity 40-50 kWh; charging time DC/AC 40-50 minutes/5 hours; max power 300 hp; max torque 250 Nm; expected battery life 20 years/320,000 km; equipped with advance driving assistance system with an estimated price of 500 million rupiahs;
4. Integration of conjoint analysis with ECQFD provides an electric vehicles design execution guide which has two advantages, namely reflecting consumer desires and at the same time realizing electric vehicles as environmentally conscious products.

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