

The Impact of Power Source to the Outline Design of a Kei-Car Segment

A. A. Abdul Rashid¹, Mohamad Hariri Abdullah²

¹Centre of Postgraduate Studies Faculty of Art and Design University Technology MARA, Shah Alam, Selangor.

²Dept. Industrial Design, Faculty of Art and Design University Technology MARA, Shah Alam, Selangor.

Abstract--In today's world, power source have become a significant concern not only for moving a car but in contributing to healthier environment. Following that, a number of power sources have been developed such as the conventional combustion with various types of fuel including petroleum, hydrogen and ethanol, electric powered such as solar generated, plug in electric and fuel cell. In the design context, it can be said that the existence of various power sources have created an impact not only to the package of a car but also to the outline design of the car, the compartments and mechanism which need to be considered during the design process. Therefore the vehicle shape and form will affect the characters that intentionally or unintentionally able to represent the type of power source underneath it. This phenomenon created some flexibility while giving opportunity to break boundaries for car designers in designing cars. Since then, car manufacturers try to predict and make statement on what their intention might be with these varies power sources in hand. After conducting interviews with several automotive designers and academician from automotive industry in Malaysia, the finding shows that the majority agree the power source can create impact to the outline design of a car. These impacts not only give some flexibility and create opportunity in designing but also can break the norm design profile of the Kei car which surprisingly became the most common segment for urban life due to its features and characters. With the needs of light weight car (Kei in Japanese) and small in size, with the complement by non-pollution power source like plug in electric and fuel cell, Kei electric version are projected to be the growing segment in future but the main question is the Kei car can be any different in future?

Index Terms-- Impact, Power Source, EV, electric vehicle, ICE, internal combustion engine, ICEV, internal combustion vehicle, Hybrid, SV, solar vehicle, Outline Design and Kei-Car

I. INTRODUCTION

HUNDREDS years ago, when an EV (electric vehicle) was first introduced, they looked totally different than gasoline powered vehicle. As described in [11], during the age of a horseless carriage, electric vehicle looked even more like a carriage. Furthermore, their shape looking like an upright box shape just the image that today designers try to avoid. As mentioned in [11], the 2012 North American International Auto show in Detroit represent one of two design philosophies; either making it exciting or making it familiar. Today, there are varies type of power source such as solar, battery powered, plug in hybrid, and fuel cell electric that been place in the Kei car.

As stated in [12], Suzuki, Daihatsu and Mitsubishi are developing and testing electric Kei-cars for the future. With the increased awareness and orientation towards environment protection along with the positive response to the Mitsubishi i-MiEV Electric Kei Car, electric micro cars are projected to be a growing product segment. Along with rapid development of power source, there are several changes and consideration took place, in this case, the form and outline design of a car as shown in Fig. 1.

We can clearly see the differences, when it comes to electric power source, the compartments will not be the same with the one using fuel combustion due to the use of lithium ion batteries and motor to generate electric vehicle hence, can give opportunities for new package. In addition, stated in [6],

"We've long argued that the current car-making paradigm is dictated by the technology that underpins it, and the moment you change the technology in a fundamental way, such as the power train, then the way you make cars will change too. It will take a while, but in 20 to 30 years, you will see that change in the industry".



Fig. 1. Different power source have different flexibility of design opportunity

II. DEFINITION OF KEI

Malaysia receives a fairly good solar insolation throughout the day even during rainy days with four peak-sun-hour on a sunny day as mentioned in [3]. City car is a small car for urban use which has greater speed and safety protection features as compared to micro car or bubble car that allow to be driven on mixed traffic environment with any weather condition [1]. In Europe, there are other terms that can describe this type of segment called quadricycle that divided into two, light (L6e) quadricycle and heavy (L7e) quadricycle [5]. In US, low speed electric vehicle are classified as Neighborhood Electric Vehicle (NEV) designed purposely for city use only due to it do not pass the crash test for greater speed that enable this segment to be driven on highway or

bigger city [4]. While in Japan, there is a specific terms and own specification for light weight city car called Kei-car [4] According to Japan government [13], any vehicle produced to comply with Kei regulations have certain benefits including tax advantages. Basically, it's either minivan, truck, passenger cars or even sport car that produced to comply with Kei-regulation can be classified as a Kei. The Kei regulations limit the specifications as describe in Fig. 2.

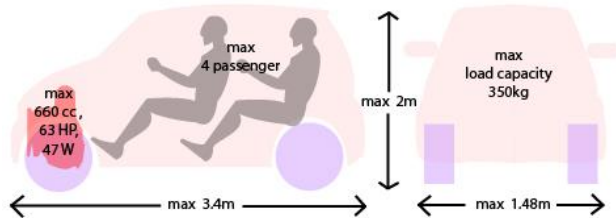


Fig. 2. Starting in 1998, Japan government confirms the Kei-car regulation as shown above.

III. EXAMPLE OF CITY CAR

There are many car manufacturer throughout the world that been producing small and light weight car for city either using electric or combustion, conceptual or production, for example, as describe in Table-1 and Table-2.

TABLE I
Japan's Kei-car









Japan	
Brand	Model
Toyota	FT-EV II 
Daihatsu	PICO EV 
Mitsubishi	MIEV 
Suzuki	wagon r (ICV) 

TABLE II
Europe's Kei car

Europe	
Brand	Model
Renault	Twizy 
Smart	For Two 
Innovative Mobility Automobile (IMA)	German 
Dok-ing (Croatia)	Loox 

IV. DIFFERENT TECHNOLOGY AND POWER SOURCE HAVE DIFFERENT SHAPE, FORM AND OUTLINE DESIGN FOR CONSIDERATION

As stated in [2] the functional objectives will influence the priorities of the package for example for certain cars, power and performance are the high priority so the power train may dominate the architecture. In other word, the purpose of a car will have differences and own priority for consideration such as when designing a city car, it should have lower performance, small size and bigger space for occupant while on the other side, when designing a solar car, it should have bigger space for solar panel, lower ground clearance and more consider on aerodynamic aspect.. This shows that not only power source and technology can create impact with or without intention, but also have its own different priorities for consideration. According to [8], Renault's Twizy is an 'amazing' breakthrough design that might very well make the category fashionable and vehicles powered by electricity can provide an opportunity for a complete rethink of a car design besides than giving advantages to the environment. For example, as mentioned in [6], Nissan Pivo city car concept as shown in Fig. 3 have a unique priority which is its cabin can rotate 360 degree so that the driver do not need to face backwards when reversing.



Fig. 3. Nissan Pivo; ability to rotate 360 degree due to the advance technology used for power train

Furthermore, power source has an impact not only to the skin but also to the outline design of a car. As an example, as shown in Figure-3, in the past, Honda had produced a N360 kei car model which is using combustion, hence, cause it to have a big space for engine bay like most of the kei car do. In 2009, Mitsubishi started to produce electric version of kei-car which is Miev that have different outline due to the compartments position and power source used. When it come to Nissan Pivo, its outline design is totally different due to it have greater advance technology as comapred to others. This shows that there is an impact to the outline deisgn of a car that designers should aware and consider as shwon in Fig. 4.



Fig. 4. 1976 Honda N360 (left), 2009 Mitsubishi Miev (middle) and 2005 Nissan Pivo 1st concept (right)

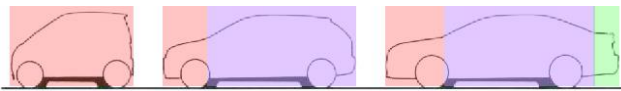


Fig.5 .The outline design comparison using boxes principle

Cars are designed and categorized based on boxes principle; one box, two box and three box as shown in Fig.5. Most of the car that used combustion engine is either two box or three box due to the need of engine space in the engine bay at the front area. For the EV, there is flexibility due to the reduction of certain compartments such as engine and big sized radiator. On a contrary, there is a need of big sized battery and small motor for EV that usually located at the bottom, hence cause differences between EV and ICEV. This has not only cause an impact but also a freedom to rethink when designing the side package. Besides than that, as mentioned in [2], the car profile are influenced by three important compartments, the occupant, cargo and the powertrain packages to create its own functional objectives and proportion hence create new packaging opportunities. For example, when it comes to ICEV, there is a need for engine bay, but when it comes to EV that using motor powered by battery underneath it, there is a space of unused engine bay that can be fully use for maximizing the occupant space. As compared to solar generated, there is a priority for bigger space for solar panel usually located on the roof. There is lots of changes take place in compartments when using various power sources as shown in Fig. 6.



Fig.6. The comparison of powertrain between the ICV (left) and the BEV (Middle) and Solar (right).

V. DIFFERENT AND EXPECTATION AMONG CONSUMER TOWARDS VARIES SOURCES OF POWER

According to [6], years ago, Honda tried to compete with Toyota’s hybrid pioneer, Prius, by producing Civic hybrid using Civic conventional body and structure as shown in Fig. 7 and the feeling was that they missing out because it didn't look different enough.



Fig.7. Civic hybrid (left) and Civic (ICV) sharing the same platform, structure and outline

Along with designing, we also need to spark the idea of expectation from the consumer as well. Moreover, as stated by [6], "Faced with a contradictory design brief for the initial concept, product chief designer Masato Inoue had to find a compromise between a 'real-world car that can be appreciated by conventional car users comfortably' and an 'iconic design that can be identified as ad electric vehicle instantly'". Referring to the success of the odd-looking Prius and the equally unusual-looking Mitsubishi MiEV, is that the customer wants a different vehicle to look different and that by producing an advance technology but using similar conventional car shape and design might cause an unimpressive expression among consumers [6]. Furthermore, [6] mentioned that people like driving Prius as shown in Fig. 8 because it looks different as compared to traditional shape of cars and its shape able to communicate and express the technology underneath it.



Fig.8.Toyota Prius side profile able to compliment the need of aerodynamic and reducing drag while giving the impression that this is a different car with different technology.

VI. THE DESIGN AND CHARACTER OF A CAR ABLE TO REPRESENT THE TECHNOLOGY USED

Besides than outline design, the character, detailing and features of a car able to represent the technology underpin it. According to [8], rather than just designing or styling, we need to understand and consider the differences of the product semantics between EV and ICEV, for example as shown in Fig. 9, the front grill of EV Avid Cue-V isn't needed to cool the engine, so the face can be redesigned to state that this is an advanced technology.



Fig.9. The differences of the front end between EV Avid Cue-V (left) and ICV Perodua Myvi (right)

As stated by [7], electricity has once again become serious concern among car manufacturer but the main question is will the design of these new carriages will be any different? Furthermore, EV's product architecture can be different from the current dominant design due to having different technologies, system and mechanism and these differences can free up tremendous space in the engine bay for instance and allow new physical configurations for existing components [14]. Further to this, EV have its own criteria, character and priority that in the end, able to speak on its own design language such as "i am different than you think i am" or "im different than my sibling, the ICEV". The real challenge of automotive designers is not the creation of radical new shapes, but rather the development of a new design language for a vehicle's details, where these elements able to communicate the technology used [12].

VII. DESIGN PACKAGE AND LAYOUT GIVE DIRECT EFFECT TO OUTLINE DESIGN OF A CAR

According to [3] when describing about Lamborghini Muira, they did mention "engine's displacement give the direct effect on the cars appearance". Moreover lithium ion battery is big in size and heavy hence it is common to package the whole system under the floor hence create a thicker platform with high occupant package and create better stability due to lower gravity point [2].

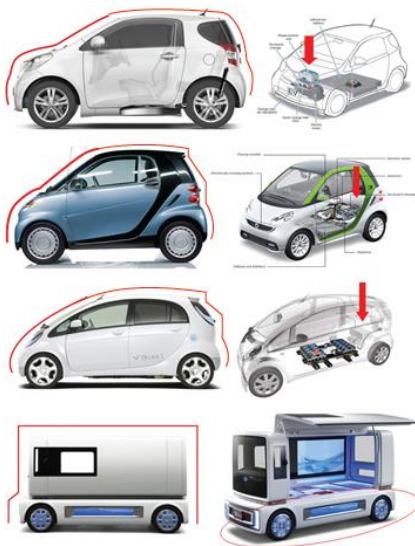


Fig.10. The outline comparison between city car that have different power source, package and layout.

According to [6] "if you just do something such as sticking fuel cell in a Ford Monro for example, it's misleading, because it gives the impression that it's the same vehicle as a conventional internal combustion engine car". As stated by [10], the functional design that already becomes dominant is not necessarily the only format that provides functional utility or need to be strictly followed. Although manufacturing remains central to the automotive industry, flexible operations and emergent technologies have allowed flexibility among development teams as shown in Fig. 10.

VIII. RESULTS

To support these theories, interview had been conducted involving several automotive academician and designers from automotive industry in Malaysia by addressing selected questions.

Research Questions 1:

Do you agree that power sources can create impact to the outline design of a car?

Majority of participant agreed that the power source can create the impact to the outline design of a car. Therefore the designers need to use their creativity to maximize the use of space in their design.

TABLE III
Respondent's feedback from question 2

Participant 1	The system, technology and compartment will be different in terms of shape, size and function on each power sources.
Participant 2	By relocate and rearrange the compartment giving more capacity especially to occupant area because there are differences in format and structure used by in power source.
Participant 3	Eliminating the compartment that is not needed hence giving more spaces and freedom to rethink the shape.
Participant 4	The size of the heart is important to represents the outlook of a car. Packaging may affect the dimension of the car too.

Research Questions 2:

How the power source can create impact to the outline design of a car?

Research Questions 3:

Do you think that the existence of various power sources today can break boundaries of the norm design profile of a car?

TABLE IV
Respondent's feedback from question 3

Participant 1	Yes because one of the reason is you can eliminate what compartment is needed and what is not needed
Participant 2	Yes. New design will come along with new technology
Participant 3	Yes. ICEV have its own format and package but come new technology, it give more flexibility to explore
Participant 4	Yes if designer can come out with a new solution and trend which is unique and novel, and give an impact the eyes of the user and the manufacturer, it can create a new segment and it may affect the norm shape too.

Research Questions 4:

Do you think that the differences created can project the future in car design?

TABLE V
Respondent's feedback from question 4

Participant 1	Yes. By simplifying the shape of the original one.
Participant 2	Yes. Because Designs will always moving forward
Participant 3	Yes. Because it, giving the idea to people that this design is the next possibility.
Participant 4	Yes. Car is always evolve in every period and in coming year's power source may become one of the reasons of the shape evolution.

IX. DISCUSSION

The results show in general, automotive designers and academician agree that power sources have an impact to the outline design of a car. This phenomenon happened due to several factors such as the differences in mechanism size that each power source need hence cause differences in shape, form and outline design. What is needed in ICEV may not need in EV or SV or vice versa. In addition, every power source has its own flexibility in terms of structure and format that designers and engineers need to consider in order to serve its purpose. Further to that, the results also shows that automotive academician and designers agree, with the existence of various power sources today it can break the boundaries of the norm design profile of a car we been using for almost 100 years and agreeing that these differences are able to project the future in car design.

X. CONCLUSION

For the past decades, car industries have gone a series of

evolution due to the development of technology and also the invention of power source such as electric, combustion and solar. The early decision of combustion is due to the demands and needs of speed, power and long distance travel. Since then, automotive designers and engineers been establishing and improving what we called a car today. What we see now is the most optimum shape a car can have.

This phenomenon happened due to several factors including the cost, safety concern and manufacturing constrain but this do not mean that a car will continue to look like that especially the boxy shape Kei car. With the coming technology like solar and plug in electric, most of it has some flexibility and opportunity they can offer hence, giving an impact to the overall shape of the car.

There is no needed for Kei car to look like what they looked right now, boxy shape like. Kei car can be different depending on what type of power source they used hence, creating its own character and language. In conclusion, with the upcoming technology consideration, we need to get over the design tradition and move to more iconic and desirable design that can attract attention in a longer period with a better expectation.

XI. REFERENCES

- [1] Sfetcu, N. 2014. The Car Show. Nicolae Sfetcu, 2014.
- [2] Macey, S., & Wardle, G. 2008. Electric Drive, H-Point.
- [3] Slade, T., Philips, A., Holmes, H., & Berg, I. 2008. Ultimate Cars, Lamborghini Muira (1966-1972), 184.
- [4] Boxwell, M. 2014. The Electric Car Guide - 2015 Edition: Discover the truth about owning and using electric cars. Greenstream Publishing Limited.
- [5] Nathan, S. 2010, September 6. Electric Vehicles: Driven by Design. The Engineer. Retrieved from <http://search.proquest.com.ezaccess.library.uitm.edu.mydocview/749667271?accountid=42518> [ProQuest UiTM Online Database]
- [6] Stones, J. 2010. Car Design. The Body Electric. Design Week. Retrieved from <http://search/proquest.com.ezaccess.library.uitm.edu.my/artshumanities/printviewfile?accountid=42518> [ProQuest UiTM Online Database]
- [7] Anonymous. 2010, November 18. Car Design: Electric Shift. Design Week. Retrieved from <http://search.proquest.com.ezaccess.library.uitm.edu.mydocview/807401423?accountid=42518> [ProQuest UiTM Online Database]
- [8] Townsend, J. D., Montoya, M. M., and Calantone, R. J. 2011, May. Form and Function: A Matter of Perspective. Journal of Product Innovation Management, 28:374-377, Retrieved from <http://onlinelibrary.wiley.com/doi/10.1111/j.1540-5885.2011.00804.x/references>
- [9] Patton, P. 2012, January 27. Should electric cars look electrifying?. The New York Times, Pg. DT11. Retrieved from <http://www.nytimes.com/2012/01/08/automobiles/its-electric-should-it-look-electrifying.html?pagewanted=all&r=0> [Lexis Nexis UiTM Online Database]
- [10] Frost & Sullivan Press Release. 2012. Electric Kei Cars Likely To Be A Growing Product Segment in Japan Due To Increased Awareness Towards Environment Protection. Frost & Sullivan. Retrieved from <http://www.frost.com/prod/servlet/press-release.pag?docid=271487902>
- [11] Japan Automobile Standard Internalization Centre 2011. GRSP informal Group on a Pole Side Impact GTR PSI 4-XX. Japan Proposal and Research Plan Retrieved from <http://www.unece.org/fileadmin/DAM/trans/main/wp29/PSI-04-11.pdf> [power point slide]
- [12] Dr. Hoeltz. 2010, December. Looking ahead: The Emergence of an Electric Vehicle Industry. Deloitte Consulting, Retrieved from http://siepr.stanford.edu/system/files/shared/pubs/papers/EmergenceofElectricVehicleIndustry_Appendix.pdf