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Ultra-Compact Electric Vehicle Behaviors in Japan

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Summary

In recent years, the countermeasures of the transportation sector against global warming are urgently required. The spread of ultra-compact electric vehicle with excellent environmental performance is one of the countermeasures in the spotlight. In this study, we conducted measurements on 37 ultra-compact electric vehicles actually used in Japan and analyzed the usage characteristics. The results show that the battery capacity installed in the vehicle can not be fully utilized on average except for part of the Delivery and Nurse visit. Charging multiple times a day is rare. On the other hand, frequent charging was conducted in the pizza delivery.

Keywords: BEV (battery electric vehicle), light vehicles, user behaviour, energy consumption, environment

1 Introduction

In recent years, the countermeasures of the transportation sector against global warming are urgently required. The wide-spread of electric vehicles is accelerating globally. The spread of ultra-compact electric vehicle with excellent environmental performance is one of the countermeasures in the spotlight. The Ministry of Land, Infrastructure and Transport (JAPAN) supports the introduction of ultra-compact mobility since 2013 [1], and over 7,000 ultra-compact electric vehicles are used in various regions of Japan [2]. In order to clarify the targets to which ultra-compact electric vehicles should be popularized and to encourage popularization, it is necessary to understand the effect of existing users' CO_2 reduction and usage patterns. Authors have been evaluating the electric consumption rate and the CO_2 reduction effect of ultra-compact electric vehicles [3], [4], [5]. However, although there are reports on usage patterns on electric passenger cars [6], [7], reports on ultra-compact electric vehicles' usage patterns are rare. In this study, we conducted measurements on 37 ultra-compact electric vehicles actually used in Japan and report on usage characteristics obtained by analyzing the data.

2 Measurement

2.1 Target model

In this study, as the target model of ultra-compact electric vehicles, COMS (Toyota Auto Body Co., Ltd.) which have the largest number of users in Japan were selected. We developed the on-board measuring device for COMS [5]. Table 1 shows the specifications of COMS and Figure 1 shows the appearance of COMS.

2.2 Overview of measurement

Table 2 shows an overview of the measurement. The measurement was conducted across nine prefectures, taking into account that no regional bias occurs. The first measurement started in November 2017, and the last measurement ended in December 2018. We asked COMS users for research cooperation on the premise that each measurement period could be secured for more than one month. As a result, the measurement days of each vehicle were 46 to 181 days. Data for as wide a range of uses were collected as possible so as to avoid bias. The applications of COMS were Delivery (beverage delivery and pizza delivery), Nursing visit, Outside duty (clerical outgoing and newborn baby visit by municipality), Tourist rental and Variety use (personal and variety use in a mountainous area). Totally, data of thirty-seven COMS were collected.

Table1: Specifications of measured ultra-compact EV [5]

riding capacity	1 person
length	2.4 m
width	1.1 m
hight	1.5 m
weight	400-420 kg
movable load	30 kg
max speed	60 km/h
full charge range (constant speed at 30km/h)	68 km
full charge time	approximately 6 hour
rated motor output	0.59 kW
max motor output	5 kW
max torpue	40 Nm

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Figure1: Appearance of measured ultra-compact EV

Table2: Overview of measurement

Prefecture	Measuring Period		Measuring days	No. of Vehicle	Application
	Start	End			
Osaka	1-Nov-2017	16-Dec-2017	46	2	Outside duty (clerical outgoing)
Hyogo	9-Feb-2018	11-Apr-2018	62	10	Delivery (beverage)
Okayama	19-Apr-2018	7-Jun-2018	50	3	Variety use (personal and variety use in mountainous area)
	19-Apr-2018	8-Jun-2018	51	2	
Tottori	14-May-2018	9-Aug-2018	88	3	Delivery (pizza)
	14-May-2018	9-Aug-2018	88	2	Outside duty (clerical outgoing)
Yamaguchi	16-Jun-2018	5-Dec-2018	173	1	Outside duty (clerical outgoing)
	16-Jun-2018	5-Dec-2018	173	2	Tourist rental
	17-Jun-2018	14-Dec-2018	181	2	
Kanagawa	17-Jul-2018	15-Oct-2018	91	2	Nursing visit
Tokyo	20-Jul-2018	15-Oct-2018	88	3	Nursing visit
Saitama	31-Aug-2018	20-Nov-2018	82	2	Nursing visit
Kumamoto	31-Aug-2018	11-Nov-2018	73	1	Nursing visit
Nara	7-Sep-2018	12-Nov-2018	67	2	Outside duty (newborn baby visit)

3 Results and discussion

The data were classified by application and analyzed the characteristics of usage.

3.1 Occupancy rate

Figure 2 shows the distribution of the occupancy rates by the applications. The occupancy rates were calculated as a ratio of driving days to measuring days. Delivery followed by Nursing visit has high occupancy rates at 0.5 to 1.0 because they use the ultra-compact EV in day-to-day work. On the other hand, the occupancy rates of Outside duty are low which are in the range of 0-0.4. It becomes clear that the ultra-compact EV is not used frequently as the application of Outside visit.

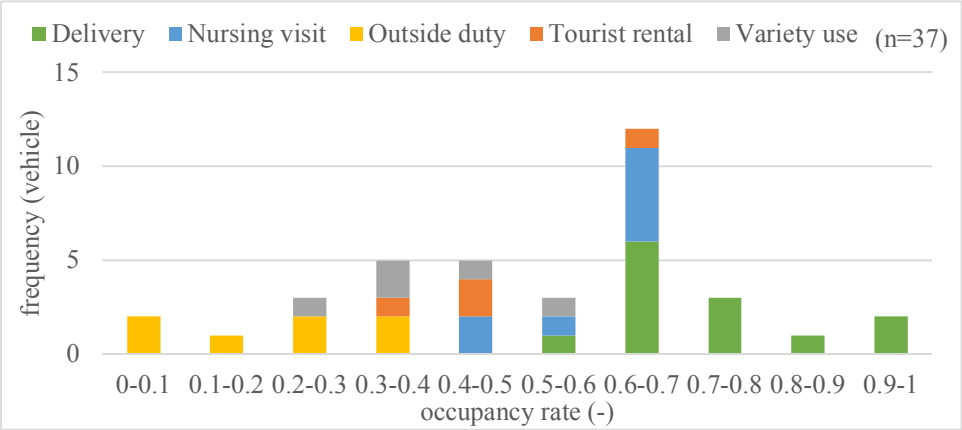

Figure2: Distribution of occupancy rate

3.2 Number of trip per driving day

Figure 3 shows the distribution of the trip number per driving day by the applications. In this paper, one trip means the traveling between vehicle's key-on and key-off. The distributions were clearly separated for Delivery and other applications. In the case of Delivery, the number of trips is large because it travels through multiple delivery destinations or repeats the round trip (itinerating type delivery) between the delivery base and the delivery destination (reciprocating type delivery). The highest value is 26.8 trips per day, which indicates that many delivery destinations are being visited for Delivery.

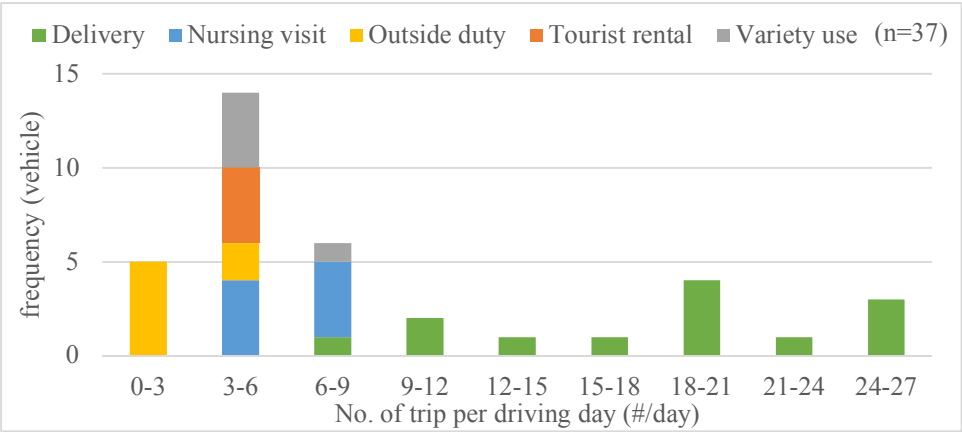

Figure3: Distribution of trip number per driving day

3.3 Average trip distance

Figure 4 shows the distribution of the average trip distance by the applications. The average trip distance of each vehicle was in the range of 0.5 to 5 km, and no clear relationship with the application was found. However, the distribution of Delivery is a bimodal distribution, and in detail, the side with the long distance is the reciprocating type of pizza delivery, and the short side is the itinerating type of beverage delivery.

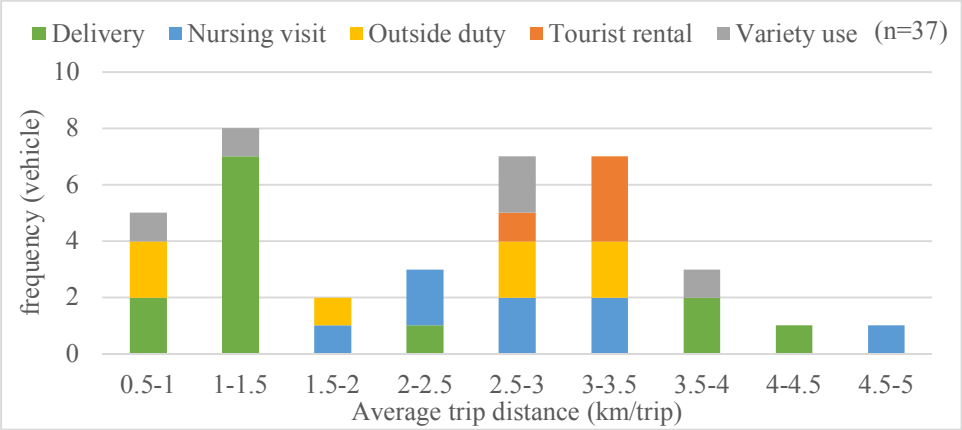

Figure4: Distribution of average trip distance

3.4 Travel distance per driving day

3.4.1 Average travel distance

Figure 5 shows the distribution of the average travel distance per driving day by the applications. The full charge range of COMS is 68 km at 30 km / h stationary driving and about 40-50 km at actual driving. The average travel distance for Delivery, Nursing visit, Outside duty, Tourist rental and Variety use were 15 to 50, 5 to 40, 0-10, 5-15 and 5-15 km/day, respectively. It is suggested that the battery capacity installed in the vehicle can not be fully utilized on average except for part of the Delivery and Nurse visit.

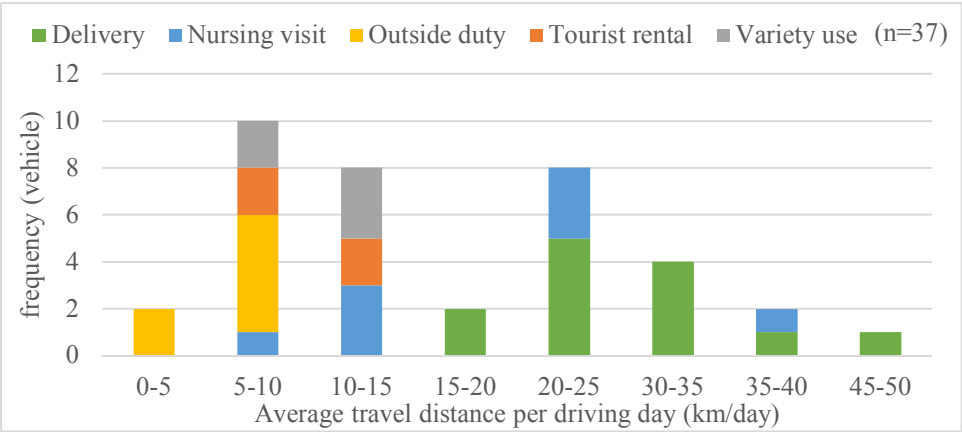

Figure5: Average travel distance per driving day

3.4.2 Maximum travel distance

Figure 7 shows the distribution of maximum travel distance per driving day by the applications. The highest frequency is in the 40 to 50 km range. On the specific day where the driving distance is long, it seems that the battery capacity is fully utilized. Furthermore, there are also vehicles that are driving beyond the full charge range on applications for Delivery, Nursing visit and Tourist rental. It is considered that 50 to 100 km/day traveling could be achieved by performing multiple charging per day.

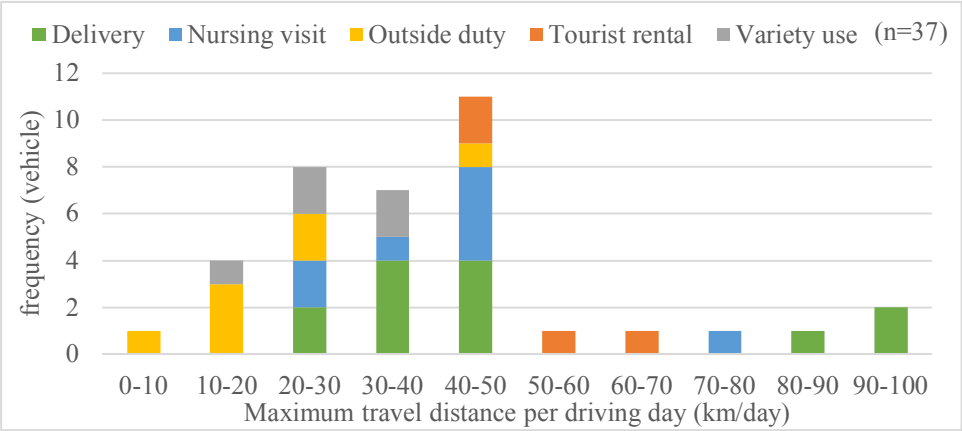

Figure7: Distribution of maximum travel distance per driving day

3.5 Number of charging per charging day

Figure 8 shows the distribution of charging number per charging day by the applications. There are 35 samples except for the two samples missing charging data. 28 samples were charged 1 to 1.5 times a day. For the most ultra-compact EVs, it becomes apparent that charging multiple times a day is rare. Although the number is small, an example of a frequently charged application is pizza delivery. Pizza delivery frequently returned to the delivery base (reciprocating type delivery) and ultra-compact EVs were charged each time in preparation for the next delivery.

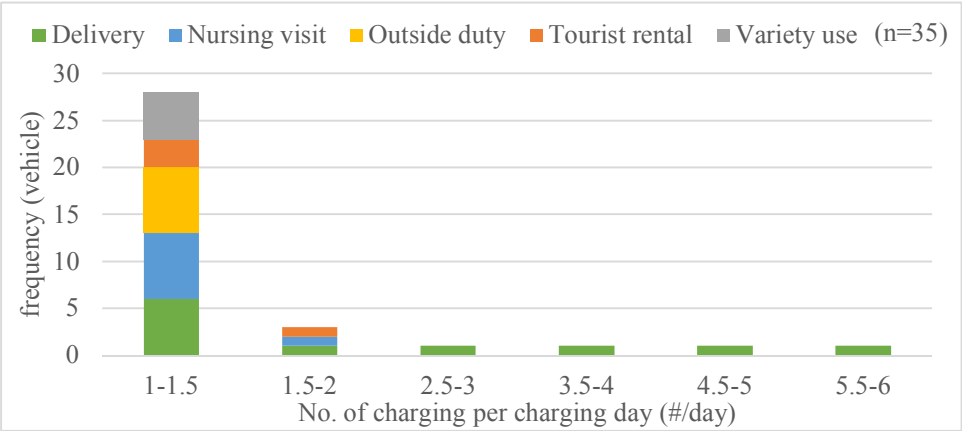

Figure8: Number of charging per charging day

3.6 Energy consumption rate

Figure 10 shows the distribution of the energy consumption rates by the applications. The energy consumption rates were calculated from the travel distance and the amount of charging electric energy between after the completion of the first full charge and until the end of the final full charge. There are 33 samples except for 2 samples which were not fully charged twice or more during the measuring period. The energy consumption rates varied from 65 to 165 Wh / km, widely. Although there are various factors other than the applications, the energy consumption rates tend to have a large value in beverage delivery. Beverage delivery is itinerating type delivery, and since it carries as many goods as possible at one time, it is also considered as a factor that the load weight is larger than other applications.

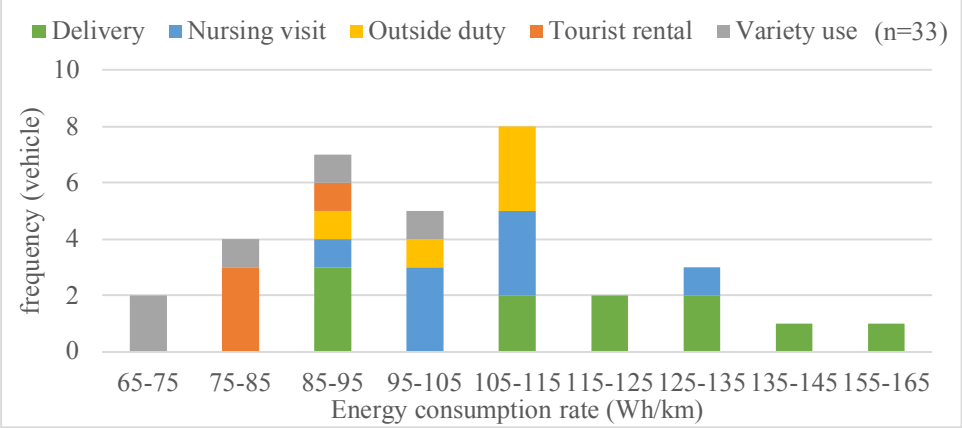

Figure10: Energy consumption rate

4 Conclusions

In this study, we conducted measurements on 37 ultra-compact electric vehicles actually used in Japan and analyzed the usage characteristics. The results show that the ultra-compact EV is not used frequently as the application of Outside visit. Many delivery destinations are being visited for Delivery. The battery capacity installed in the vehicle can not be fully utilized on average except for part of the Delivery and Nurse visit. On the specific day where the driving distance is long, the battery capacity is fully utilized. Charging multiple times a day is rare. On the other hand, frequent charging was conducted in the pizza delivery. The energy consumption rates varied from 65 to 165 Wh / km, widely.

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