

Investigation of Demand for Electric Vehicles in China

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ABSTRACT

Electric vehicles (EV) are expected to play an important role as next-generation mobilities. Honda, in cooperation with the People's Government of Guangzhou Municipality in the People's Republic of China and the Guangzhou Automobile Group Co., Ltd., has conducted a social field test using EV with the aim of popularizing new energy vehicles. The results confirmed by this field test and the results of user surveys showed that although EV have lower running costs than gasoline vehicles and are also eligible for preferential treatment as new energy vehicles, users feel some unease and hesitate to purchase EV due to short driving ranges and a lack of charging locations in urban areas, so demand remains latent. In addition, it was also found that users do not fully understand the technical safety aspects of the lithium-ion rechargeable batteries used in EV. In order to elicit demand for EV in China, it is necessary to enhance performance such as driving ranges, construct charging infrastructure, and address unease regarding the safety of lithium-ion rechargeable batteries.

1. Introduction

The Chinese government promoted the installation of charging facilities and other infrastructure in parallel with trial operation of new energy vehicles such as electric vehicles (EV), plug-in hybrid vehicles (PHEV) and fuel cell electric vehicles (FCV) in major metropolises from 2008 to 2012. In addition, the Plan for Development of the Energy Efficient (HEV) and New Energy Automobile Industry (2012-2020)⁽¹⁾ announced in June 2012 stated the goals of popularizing new energy vehicles (cumulative sales of five million units) and expanding the production scale (two million units/year) by 2020.

On the other hand, sales of new energy vehicles in China⁽²⁾ increased to 8,638 units (including 5,655 EV) in 2011 and 12,791 units (including 11,375 EV) in 2012. Sales for the most recent six months from January through June 2013 totaled 5,889 units (including 5,114 EV), which is an increase of 67 points (48 points for EV) over the 3,525 units (including 3,535 EV) sold from January through June 2012. Thus, it appears that new energy vehicles are starting to become popular.

Against this background, Honda conducted a social field test (field test) using EV in Guangzhou City in China from November 2011 to January 2013. This field test confirmed EV driving ranges and driving cost reduction effects in actual traffic environments, and the charging infrastructure situation and power supply quality in Guangzhou City. In addition, surveys were conducted to clarify issues such as when general automobile users (users) use EV and purchase demand (demand). This paper describes the background

of EV popularization in China and reports the results confirmed by the field test and the results of investigating conditions that will lead to increased EV demand in China based on user surveys.

2. Background and Purpose of Investigation

2.1. EV Technical Targets in Official Policies to Popularize New Energy Vehicles

The Plan for Development of the Energy Efficient and New Energy Automobile Industry (2012-2020)⁽¹⁾ announced in June 2012 stated the EV technical targets to be achieved by 2015 as follows.

- (1) Vehicle performance: maximum speed of 100 km/h or more and a driving range of 150 km or more
- (2) Rechargeable battery module performance: energy density of 150 Wh/kg or more and a cycle life of 2,000 times or more or 10 years or more

These technical targets are not yet designation criteria for new energy vehicles as of September 2013, but equivalent specifications are generally acknowledged with regards to EV driving range and rechargeable battery module life.

2.2. Subsidies and Preferential Treatment Systems for New Energy Vehicles

According to the official publication of the Central People's Government of the People's Republic of China released in September 2013⁽³⁾, EV approved to receive subsidies as new energy vehicles are eligible for preferential measures such as the following.

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The subsidies (upper limit) provided to automobile manufacturers and reflected to sales prices for fiscal year 2013 are CNY 35,000 per vehicle for EV with a driving range of 80 km or more to less than 150 km, CNY 50,000 per vehicle for EV with a driving range of 150 km or more to less than 250 km, and CNY 60,000 per vehicle for EV with a driving range of 250 km or more. Subsidies provided to automobile manufacturers for fiscal years 2014 and 2015 are calculated by multiplying the fiscal year 2013 subsidies by the coefficients 0.9 and 0.8, respectively. In addition, subsidies are also provided to purchasers from local governments. For example, Guangzhou City provided CNY 10,000 per vehicle from 2012 to 2013. Furthermore, the cities of Beijing, Shanghai, Guiyang and Guangzhou restrict the number of vehicles registered due to concerns over chronic traffic congestion in urban areas and environmental issues. However, new energy vehicles are eligible for preferential measures during vehicle registration, such as the establishment of a separate category. Guangzhou City has restricted the number of vehicles registered since 2012, and persons planning to purchase a vehicle need to either win a free lottery or apply with a minimum bid of CNY 10,000 in order to register the vehicle. However, the 2012 and 2013 limits for the number of new energy vehicles registered were set separately from the limits for gasoline vehicles and there were also few applications, so new energy vehicles could be registered free of charge without a lottery.

2.3. Purpose of Investigation of EV Demand

In April 2011, Honda signed a memorandum concerning the joint promotion of the new energy vehicle industry with the People's Government of Guangzhou Municipality and the Guangzhou Automobile Group Co., Ltd. A social field test and investigations of charging infrastructure aimed at popularizing new energy vehicles were then promoted jointly based on the provisions of that memorandum. Actual driving using EV started in Guangzhou City from November 2011, and the following items were investigated and verified.

- (1) Data was collected and verified regarding driving ranges and year-round power consumption for air conditioning in actual traffic environments.
- (2) Information was gathered regarding the planned pole-type charging infrastructure in Guangzhou City, and the current installation situation and general power supply quality were investigated.
- (3) User attitudes regarding EV usage were surveyed and EV demand was investigated.

The EV used in the field test were prototype vehicles consisting of an EV system installed in a 2008 model year FIT body. The driving range absolute values and variance were evaluated and compared with Japanese field test data, and Chinese market trends were confirmed. The charging infrastructure was investigated by on-site verification and also by exchanging information from June 2011 with each division involved with the new energy vehicle business of

the Guangzhou Power Supply Bureau of the China Southern Power Grid (Southern Power Grid), which is installing the charging infrastructure. User surveys were conducted by questionnaires and interview surveys of people visiting prototype vehicle exhibitions and test drive events in Guangzhou City, and by quantitative and qualitative surveys to confirm issues and demand for EV in major cities.

This investigation report examines whether EV that satisfy the conditions described in section 2.1 can elicit user demand based on the results confirmed by the field test and user concerns confirmed by user surveys, and confirms the conditions for popularizing EV.

3. Field Test in Guangzhou City

3.1. Overview of Field Test and Results

Urban areas in China have high traffic concentrations and experience chronic traffic congestion. Many people living in urban areas commute by car to factories and other workplaces located in designated development districts in the suburbs. In addition, rental cars are not popular, so visitors on business trips and foreigners are generally driven to and from airports. In consideration of this vehicle usage environment, driving courses were set as shown in Table 1 and a field test was conducted using three EV. The following results were confirmed.

The EV driving range per full charge averaged 169 km as shown in Fig. 1. The center values and upper and lower limit values of the driving range for each course confirmed that the variation was greater for the lower limit side from the center value. The driving range was shortest for the traffic jam route, but the chance of experiencing unexpected traffic congestion due to a traffic accident or a disabled vehicle was 1 percentile or less, so it is thought that there is almost no risk of running out of electricity as long as the driving distance is 100 km or less.

Figure 2 shows the year-round power consumption for air conditioning confirmed by field tests in Guangzhou City and in Kumamoto City in Japan. There was no noticeable difference when using the cooler during the summer with outside temperatures in excess of 30°C, and the power consumption was 0.5 kW in both cases. However, the temperature drops to 10°C or less during the winter in Japan, so the heater power consumption was approximately 0.5 kW to 1 kW higher than that in Guangzhou City. This result indicates that the drop in driving range during the winter due to air conditioning is less in warm regions where heater power consumption is lower compared to cold districts, which is advantageous for EV usage.

Figure 3 shows the vehicle stopping frequency on the vertical axis and the average vehicle speed for the corresponding sections on the horizontal axis when driving in urban areas as confirmed by field tests in Saitama City and Kumamoto City in Japan and Guangzhou City in China. Under urban traffic conditions with an average vehicle speed between 20 km/h and 30 km/h, the stopping

Table 1 Driving route and distance in Guangzhou area

(1) Traffic jam route in Guangzhou city

Route name	Driving route	Distance	Via points
Traffic jam route 1	Inside Guangzhou city area	20 km	Pearl River
Traffic jam route 2	Inside Guangzhou city area	14 km	Garden hotel
Traffic jam route 3	Inside Guangzhou city area	31 km	LiuHuaHu Gong Yuan, Pearl River
Traffic jam route 4	Inside Guangzhou city area	32 km	LiuHuaHu Gong Yuan, Garden hotel

(2) Commuting route to suburban work place

Route name	Driving route	Distance	Via points
Commuting route	Guangzhou city to Guangzhou Honda factory	58 km	Guangyuan Expressway

(3) Baiyun airport route via highway

Route name	Driving route	Distance	Via points
Airport route 1	Guangzhou city to Baiyun airport via highway	76 km	Garden hotel
Airport route 2	Guangzhou city to Baiyun airport via highway	130 km	Garden hotel, Guangzhou Honda factory

frequency in the Saitama urban area when travelling at an average vehicle speed of 20 km/h exceeded approximately 30%. In contrast, the stopping frequency in the Guangzhou urban area when travelling at the same average vehicle

speed was approximately 20%. The fact that the average vehicle speed was the same even though the stopping frequency was less is thought to indicate that the speed range used when driving in the Guangzhou urban area is lower than that when driving in urban areas in Japan. In addition, Figure 4 shows the power consumption minus

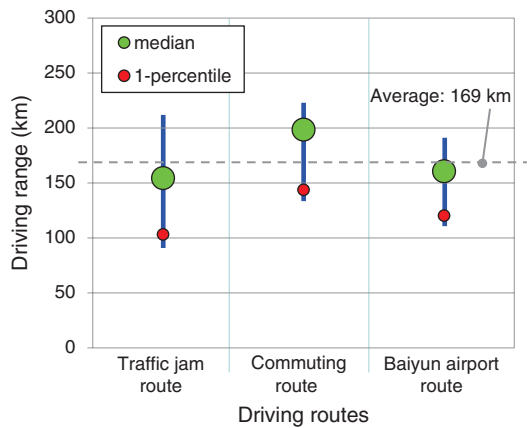


Fig. 1 EV driving range

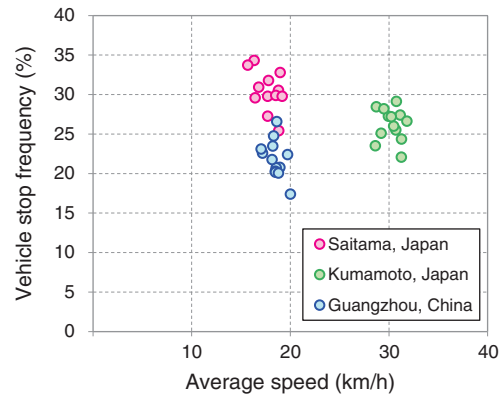


Fig. 3 Vehicle stop frequency in city

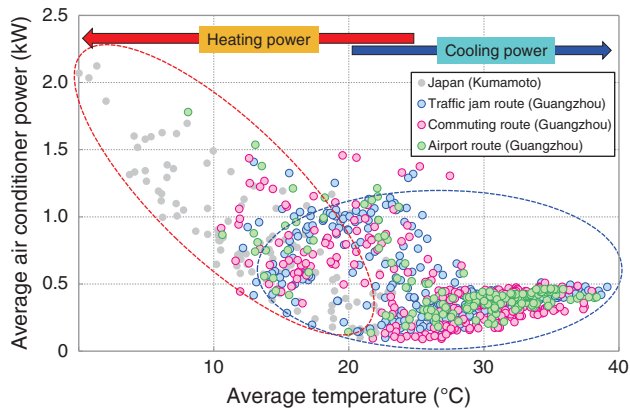


Fig. 2 Annual power consumption from air conditioning

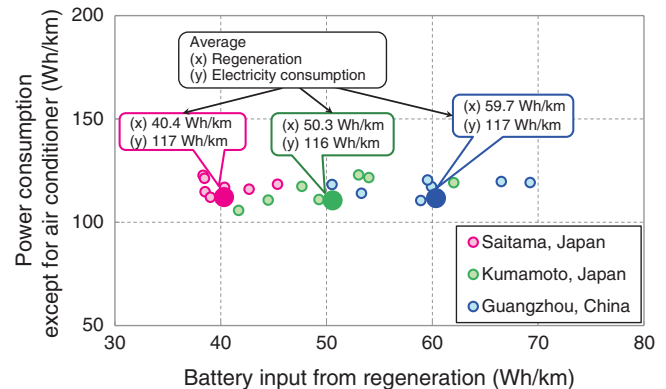


Fig. 4 Regeneration from braking in city

Table 2 Nominal electricity rate and gasoline price

City	Nominal electricity rate CNY/Wh	Regular gasoline price CNY/L	Ratio of Gasoline price to electricity rate
Guangzhou, China	0.610	7.69	12.6
Shanghai, China	0.617	7.75	12.6
Beijing, China	0.483	7.81	16.2
Yokohama, Japan	(25.19 JPY/Wh)	(149.2 JPY/L)	5.9

the power consumed by air conditioning on the vertical axis and the power recovered by regenerative braking on the horizontal axis. Regenerative braking in the Guangzhou urban area averaged 59.7 Wh/km and the driving power consumption was 117 Wh/km, so adding these together yields an energy consumption of 176.7 Wh/km for driving. Similar calculations show that energy of 157.4 Wh/km is consumed for driving in the Saitama urban area and 166.3 Wh/km in the Kumamoto urban area. That is to say, the power required for acceleration, or the power loss, is thought to be greater when driving in the Guangzhou urban area than when driving in urban areas in Japan. Therefore, technology that suppresses power consumption from launch to approximately 30 km/h should be considered to support the user environment in China.

Figure 5 shows that the annual electricity cost assuming a commuting distance of 30 km each way and 240 days of use per year (annual driving distance of 14,400 km) is approximately CNY 1,300. This is a driving cost reduction effect of approximately CNY 5,600 compared to a 2008 model year FIT gasoline vehicle of the same class, and is more than the average monthly wage for a nonmanufacturing sector general worker⁽⁴⁾. In addition, Table 2 shows the difference in electricity rates and gasoline prices between China and Japan, and shows that the price of one liter of gasoline is equivalent to electric energy of approximately 5.9 kWh in Japan and approximately 12.6 kWh in Guangzhou City. The average wage in China⁽⁴⁾ is approximately 1/4 to 1/3 that in Japan, so it is thought that the driving cost when replacing a gasoline vehicle with an EV that operates by electricity with stable supply and rates

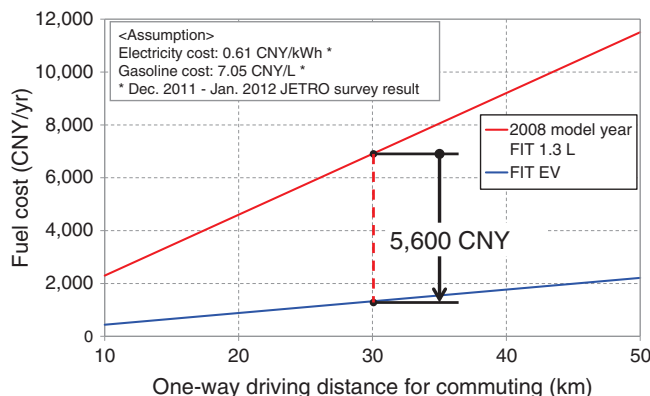


Fig. 5 Fuel cost reduction from EV in China

will seem much less expensive from a Chinese perspective compared to a Japanese perspective.

These results are thought to indicate that EV are suited to users with an estimated daily driving distance of 100 km or less who emphasize driving cost.

3.2. Technical Issues to be Addressed

Trouble occurred when charging the running battery during the field test in Guangzhou City, so the power supply quality was investigated. This investigation confirmed the following situation that should be taken into account as conditions when designing the charging functions.

Power receiving facilities equipped with a voltage converter from high voltage to low voltage such as shown in Fig. 6(a) have a power factor regulator such as shown in Fig. 6(b) on the low voltage side to reduce the contract electricity rate. When the power load becomes high, this power factor regulator automatically connects to and disconnects from the power distribution source circuit in accordance with the power factor. At this time the power supply voltage used for charging fluctuates as shown in Fig. 6(c) due to the effects of the large-capacitance capacitor of the power factor regulator.

The general power supply (AC220 V) of collective housing is distributed using a three-phase four-wire system. The TN-C earthing system is widely used, and the earth wire (E wire) of each housing unit is connected to the protective earth conductor (PE conductor) for the entire building. In the field test, cases of wiring work were confirmed where the neutral wire (N wire) is connected to ground on the side of low-power devices such as fluorescent lights. In these cases, noise from other devices is superimposed onto the E wire of devices via the PE conductor as shown in Fig. 7, even when the room power supply is wired correctly.

The on-board charger specifications were reviewed in consideration of these power supply quality investigation results. In addition, it was confirmed that a stabilized power supply that can convert from AC to DC and then to AC again needs to be added when the distortion in the power supply voltage waveform increases. Furthermore, adding commercially available reactors and ferrite cores to the signal lines was confirmed to be an effective measure against noise entering via the PE conductor.

When developing EV for the Chinese market in the future, it is thought that the power supply quality should be investigated as in this field test, and compatibility with the

charging infrastructure to be installed should be verified as appropriate.

3.3. Charging Infrastructure Layout Plan

In parallel with on-site investigation of the general power supply quality and confirmation of countermeasure effects, information was also exchanged with the Southern Power Grid from June 2011 to obtain information regarding the installation plans and layout situation of pole-type charging infrastructure. The charging system, standards and approach to power distribution of the Southern Power Grid are as follows.

(1) The Southern Power Grid is promoting the construction of battery replacement-type charging stations together

with quick charging facilities within Guangzhou City in line with the government policy aiming for popularization of battery replacement-type EV.

(2) The Southern Power Grid is also promoting the installation of pole-type charging infrastructure equipped with normal chargers and quick chargers. However, priority is being given to areas used for field tests and other requests by automobile manufacturers that are currently producing or have plans to produce EV rather than locations that take into account general use. As a precedent example, this infrastructure is already installed in the Huadu district and Shenzhen City.

(3) All charging-related standards except for test measures requested by automobile manufacturers use the national

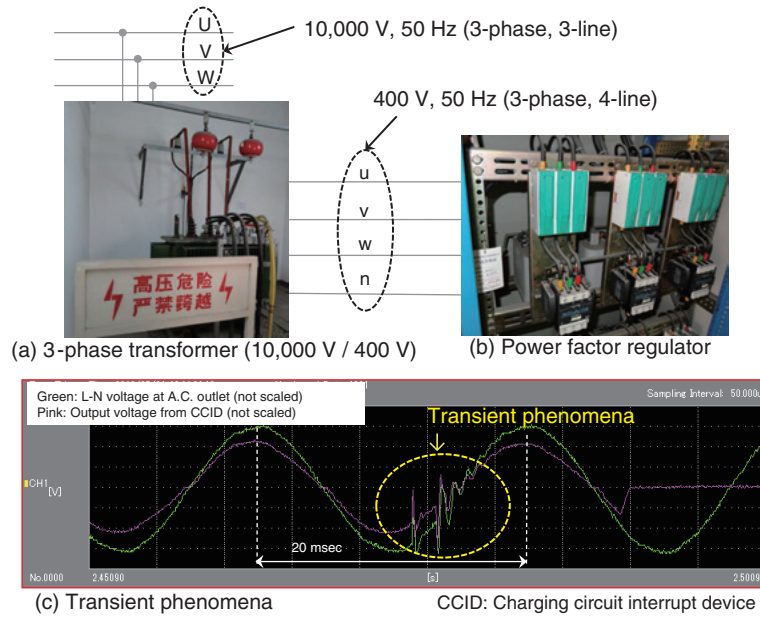


Fig. 6 Transient phenomena of voltage from power factor conditioner switching

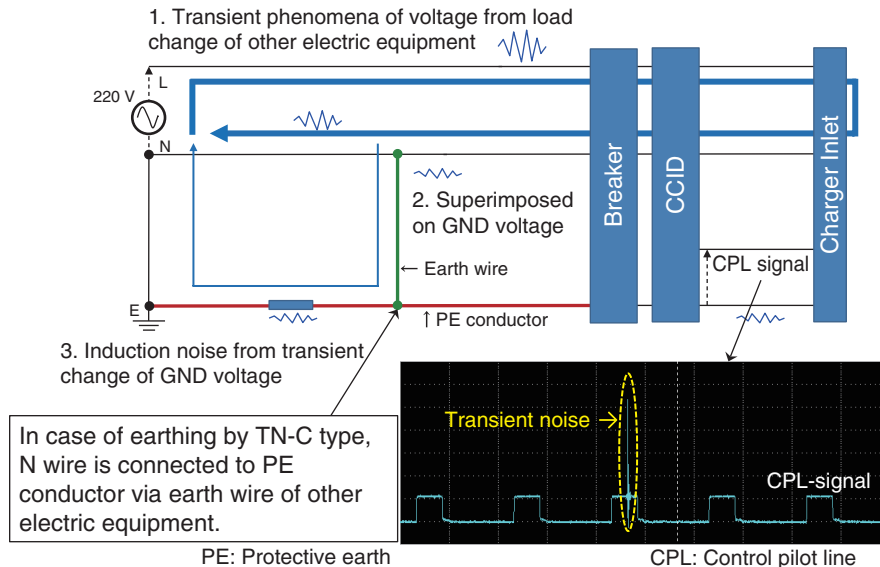


Fig. 7 Induction noise in CPL-signal from GND voltage's transient change

Table 3 Issues of EV dissemination found in preliminary survey

(1)	People will not be satisfied with EV in terms of driving distance and charging time.
(2)	People will have uneasiness from seeing almost no available charging facilities.
(3)	People will have uneasiness about technical methods for battery safety.
(4)	The battery is expensive, and thus EV are expensive.
(5)	People will think that the EV acceleration and maximum speed are insufficient.

standard (GB/T)⁽⁵⁾.

- (4) There are concerns over drops in power supply quality such as power supply voltage fluctuation within the same power distribution area when large numbers of EV are charged at the same time from general outlets (AC 220 V, 16 A). Therefore, installation of a power distribution network for charging is planned.

Pole-type charging infrastructure was not installed along the driving courses set for the field test, so there was no chance to use this infrastructure. However, the installation of charging infrastructure is essential for the popularization of EV, and requires attention in the future.

4. Investigation of EV Purchases and Usage

4.1. Results of Preliminary Survey

According to an investigation by the China Association of Automobile Manufacturers⁽²⁾, 5,655 EV were sold in China in 2011, which accounted for 0.03% of the total vehicle sales of 18,505,100 units. Given this percentage it was predicted that a reliable number of samples (n) could not be gathered for a general statistical survey concerning EV, so prospects for popularization and an image of users were obtained as an advance survey in 2012 by interviewing editors of automotive trade journals and informed authorities who had written about environmental investigations and EV. As of 2012, these authorities held generally positive attitudes toward the use of EV as a direction for replacing gasoline vehicles. However, they also pointed out the issues from the user's viewpoint shown in Table 3, and said that they felt current conditions were not conducive to expanding popularization. User surveys were conducted as described below to confirm whether there is actually latent demand for EV and investigate the actual situation regarding the indicated issues.

4.2. User Survey Results

Figure 8 shows the attributes of the subjects of the survey conducted from late April through early June 2013. The three major metropolises of Guangzhou, Shanghai and Beijing were selected as the subject cities from among the cities announced in the official publication of the Central People's Government of the People's Republic of China released in June 2012⁽¹⁾ concerning the popularization of new energy vehicles for promotion of charging infrastructure installation and provision of subsidies to purchasers. n was set at 500 for each city, for a total survey n of 1,500.

Table 4 Frequency of driving (n=1,500)

(1) Frequency of driving (%)

Almost every day	72.4
4-5 times per week	22.3
2-3 times per week	4.6
1 time per week	0.7
2-3 times per month	0.0
1 time per month	0.0

(2) Monthly driving distance (%)

Less than 100 km	1.6
100-499 km	15.1
500-999 km	22.5
1000-1999 km	33.4
2000-2999 km	14.9
Over 3000 km	12.5

Table 4(1) shows the car usage frequency. Almost every day accounted for 72.4% and four or five days a week accounted for 22.3%. In addition, Table 4(2) shows the monthly driving distance. Here, 500 km to 999 km accounted for 22.5% and 1,000 km to 1,999 km accounted for 33.4%. Calculating the average daily driving distance shows that (2,000 km ÷ 20 days) 100 km or less covers nearly all cases. Based on these results, it is thought that even EV with a driving range of approximately 100 km would enable movement without hindrance in most cases of car usage for daily living and commuting.

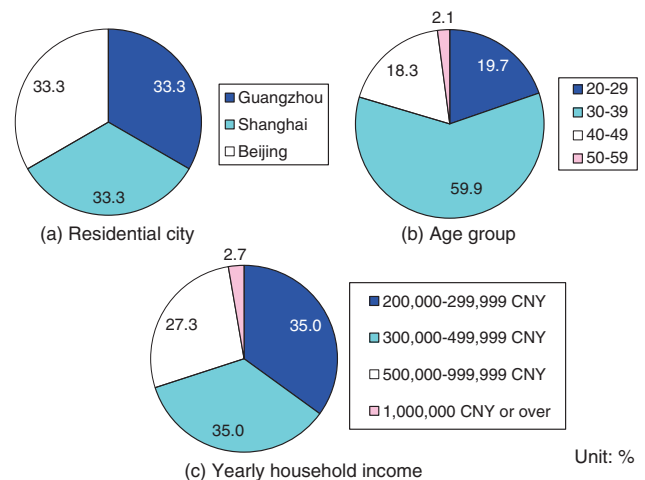


Fig. 8 Basic profiles of persons for survey (n=1,500)

Figure 9 shows that the most common purchase price range for a first vehicle is CNY 200,000 to CNY 290,000 at 29.1%. The most common budget range for the next car considered for purchase is also CNY 200,000 to CNY 290,000 at 29.9%, but the less than CNY 200,000 percentage is lower and the CNY 300,000 or more percentage is higher, which is thought to indicate a tendency toward higher grade vehicles. Figure 10 shows that the most common purchasing budget when assuming an EV is CNY 200,000 to CNY 290,000 at 33.7%, and the overall percentages are approximately the same as for currently owned vehicles. High price was noted as an issue for EV popularization in Table 3, but this result could be said to indicate that as long as the price is approximately the same as their current gasoline car, users would not feel that EV were expensive and would consider purchasing.

Figure 11 shows the desire to use EV, and a high percentage of 82.6% of users responded that they want to use very much or want to use EV. However, as shown in Fig. 12, 62.6% responded that the motive power type of the next car they were considering purchasing was gasoline, 32.5% responded HEV, and only 1.7% responded EV, so there is a large gap compared to the desire to use percentages. That is to say, EV demand is thought to be latent.

Table 5 shows the priority items (multiple answers possible) when considering EV purchase. In order from the most common, driving range per charge accounted for

Table 5 Significant points for EV purchase (n=1,500)

Significant points	%
Driving range per one charge	72.6
Battery safety	63.5
Availability of on-street charging infrastructure	62.0
Short charging time	60.9
Maintenance cost	50.1
Availability of service in case of battery trouble	46.1
Low charging cost	40.7
Can charge at home	39.1
Low purchase price	33.1
Design	27.3
Subsidy and support from government	20.9

72.6%, battery safety for 63.5%, availability of on-street charging infrastructure for 62.0%, and short charging time for 60.9%. These are actual reasons that kept users from purchasing EV, so it is thought that demand will materialize if these issues can be addressed. Note that these issues also match the issues for EV popularization indicated by the advance investigation as noted in Table 3.

Desire to use EV is high, but issues perceived by users have not been addressed, so the current situation is that the only people purchasing and using EV are early adopters, and popularization is lagging.

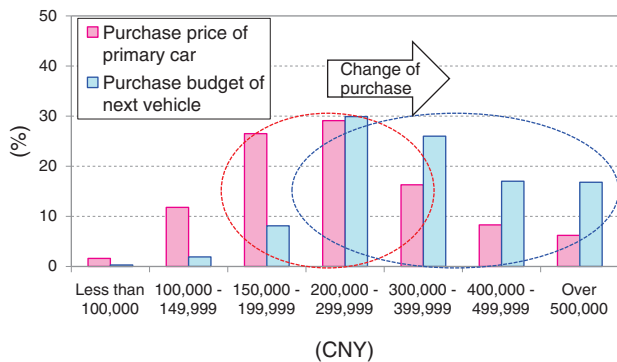


Fig. 9 Purchase price and budget of vehicle (n=1,500)

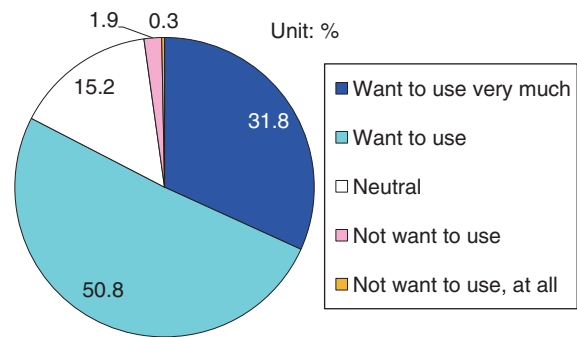


Fig. 11 Willingness to use EV (n=1,500)

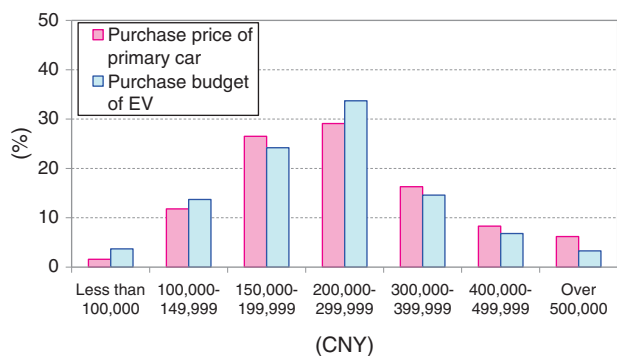


Fig. 10 Purchase budget of EV (n=1,500)

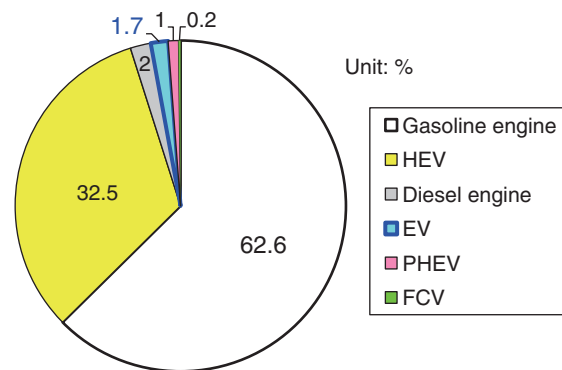


Fig. 12 Power type of next vehicle (n=1,500)

Table 6 Perception gap between Honda and prospective users

Concerns	Honda	Users
Driving range per one charge	· 100 km per day is sufficient.	· At least 80 km per day is necessary. · 200-300 km for 2 or 3 days is ideal.
On-street charging infrastructure	· Number of on-street chargers is insufficient as main charger. · Charging from electrical outlet at home is recommended.	· Number of on-street charger is insufficient. · People don't know where available chargers are.
Shortening of charging time	· Short charging time may be necessary for emergency. · In case of emergency, fully charging every night is recommended.	· Shortening of charging time is necessary. · People often forget when last charging was.
Safety technology of rechargeable battery	· Technologies to use Li-ion battery are established. · Manufacturer's warranty is provided.	· Most of people don't know safety technologies and information about Li-ion battery. · Sometimes people hear news of battery explosion.

4.3. Issues for EV Popularization

Items (1) to (3) in Table 3 that were indicated by the advance investigation were confirmed quantitatively by the prospective user survey, and qualitative research was also performed to confirm the differences from the field test assumptions and perceptions. Table 6 organizes the differences between the field test assumptions and prospective user attitudes regarding EV usage. These results confirmed that while it was assumed in the field test that EV would be charged every night at prospective users' homes, prospective users thought differently. This is thought to be influenced by the characteristic Chinese housing style whereby nearly all urban residents live in condominiums. In addition, it was also confirmed that prospective users do not fully understand the technical safety aspects of the lithium-ion rechargeable batteries used in EV.

Regarding the lack of power performance that prospective users feel is an issue, cheap and slow EV that use lead batteries are already used in China, so it was predicted that this has created preconceptions, and prospective user opinions were confirmed after having them test drive the EV used in the field test. As shown in Fig. 13, prospective user images of EV acceleration performance were fairly poor to inferior before the test drive but changed for the better after the test drive, which confirmed that there had been negative preconceptions.

The field test results described in section 3.1 and the survey results described in section 4.2 are thought to indicate that there are potential prospective users considering EV purchase and use. In order to elicit this demand, manufacturers and parties promoting EV popularization need to understand the background for prospective user assumptions and perceptions, develop technology to extend driving ranges, install charging infrastructure, explain the technical safety aspects of lithium-ion rechargeable batteries, and clear up mistaken

images concerning power performance.

Given the current situation of latent EV demand, possible approaches are as follows.

- (1) Manufacturers should work to extend EV driving ranges and also address the issue of power supply quality to enable charging from typical household outlets. If charging outlets are available at homes and workplaces where prospective users park for long periods, it is thought that the charging task will become a habit for prospective users, which will help to reduce dependence on pole-type charging infrastructure in urban areas and also reduce concerns over short driving ranges, charging locations and charging times.
- (2) Manufacturers should investigate prospective user concerns about the safety of lithium-ion rechargeable batteries and explain that proper technical measures are taken.
- (3) Manufacturers and parties promoting EV popularization should offer short test drives and rental opportunities that enable prospective users that want to use EV to confirm driving ranges, the charging task and power performance in actual usage environments.

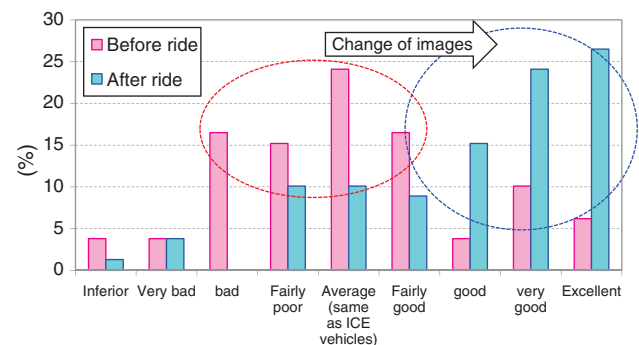


Fig. 13 Images of EV acceleration
(December 2012, Guangzhou, China,
n=79)

5. Conclusion

A field test conducted in Guangzhou City in China confirmed that given a driving distance of 100 km or less, there is almost no risk of running out of electricity, and a reduction in driving cost can be expected. In addition, it was confirmed that technology to suppress power consumption from launch to approximately 30 km/h and measures to support the quality of the typical power supply used for charging are needed to suit the Chinese market.

User surveys confirmed that approximately 70% of users have an average daily driving distance of 100 km or less, and approximately 80% responded that they would like to use EV. However, users do not see much of a charging infrastructure, so they feel that an EV driving range of approximately 100 km is short. Furthermore, users are also skeptical regarding the safety of lithium-ion rechargeable batteries. As a result, few people are considering EV as their next vehicle purchase, and demand remains latent.

In order to elicit EV demand in China, it is thought necessary to enhance performance such as driving ranges, construct charging infrastructure, and address user concerns regarding the safety of lithium-ion rechargeable batteries.

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