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Commercial solution to mass penetration of first generation battery electric vehicle in China

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Abstract

With the rapid increasing of motor stock in China, the pressure from climate changing and energy safety is more pressing and the GHG emission and fuel efficiency regulation are more rigid to initiate the electrification of the transportation. Despite the rapid progress currently being made in the global electric vehicle technologies, substantial barriers to widespread vehicle adoption still exist, such as higher price, inconvenience charging, limited range, battery environmental issues etc. In this paper, an innovative business model of battery leasing is provided and its commercial potential is analyzed as well. The new business model will pave the way for the EV rolling out in China.

Keywords: Battery electric care, mass penetration, business model, leasing battery, charging infrastructure

1 Introduction

Electric vehicles (EVs) have gained more and more attention, especially in the context of growing concerns about global warming and energy security aspects with road transport. EVs offered significant improvement in fuel economy, potential environmental benefits and decreased reliance on petroleum. With the breakthrough of battery technologies, lithium-ion EVs are on the verge of commercial viability and mass-production

1.1 Battery progress

In past 10 years, technologies of battery for EV have been improved greatly [1]. The specific energy battery system is about 80Wh/kg，cycle life being 700 and cost being 4.0Yuan/Wh. Electric motor technologies also have been improved tremendously as well.

In addition, in China, the government has placed much importance on the prompt EV industrialization, and more than 25 cities are chosen as EV demonstration cities [1]. Among them, 6 cities were chose to subside for private electric car purchasing (showed in Figure 1 and Figure.2)[2].All of above indicate that the industrialization of EV in China is coming.

1.2 Challenges of EV mass marking

However, there are still some barriers for mass penetration the first generation electric vehicles, such as high upfront cost, limited range and inconvenient using. At present, the price of battery system is about 4.0Yuan/Wh in China, and in other words, for an A0 class passenger car, at least 12kWh capacity will be required, which will cost

48 thousands Yuan. The upfront cost of EV is too high to be competitive to conventional petroleum vehicles because of the higher cost of the battery, even taking subsidy into consideration. In addition, in the EV initial rolling out stage, the infrastructures are not sufficient to ensure convenient charging.

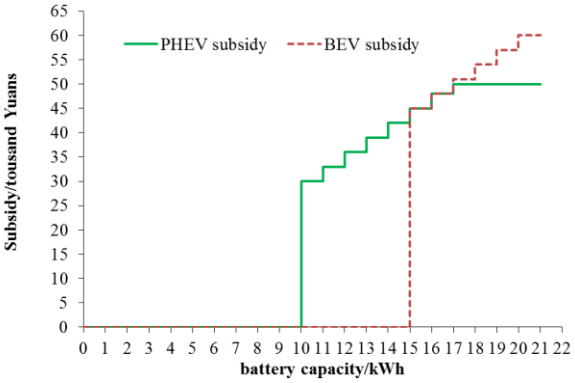


Figure 1: Government subsidy for EV purchase

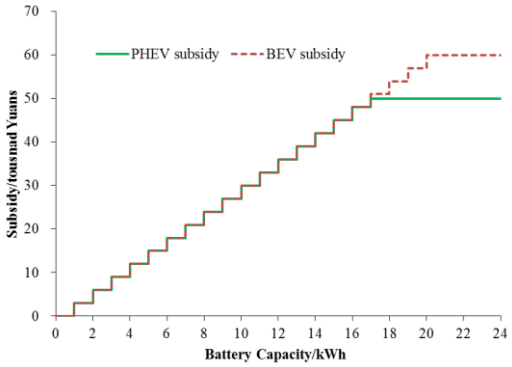


Figure 2: Subsidy for EV purchase of Beijing

Be face with challenges of EVs commercialization, the innovative solution except technologies must be taken into consideration. Many automotive manufacture in consensus that the new business model may be the solution to EV large scale rolling out. Some has been pursuing different business to open up electric vehicle market. Renault-Nissan established alliance in March 1999 to investigate method for EV mass market, and battery leasing and car leasing may be the option. Some institutes also explore car leasing and the Car club mode [4-9], etc.

2. Innovative business model

2.1 Conception description

Based on the condition of China, battery leasing would be more suitable than any others. To develop mass market of battery electric vehicle, innovative business model is provided combined with breakthrough of the battery technology improvement.

The new business model different from the conventional vehicle (CV) industry can be the solution for EVs mass penetration in China.

The innovative business model is of characteristic as follows:

First, by separating the battery pack from the vehicle and leasing the battery pack to vehicle owners, the upfront costs associated with electric vehicles can be reduced substantially and the risks associated with the technology can be minimized for vehicle users.

Second, by set up smart and dense charging net, eliminate the hurdle of EV operating. Charging at community charging poles is the mainly energy supply method of EV, assisted with public place charging. So the Level 1 charging mode is dominant. Battery swapping is the best choice to integrate with battery leasing program. At the EV mass marking initial stage, battery swapping may be the best solution to remove the consumer's range anxiety.

Thirdly, by professional battery maintaining service from battery leasing enterprise, such as performance balancing, the battery cycle life can be improve greatly and some on-board safety issue produced by battery find in advance and avoided. In addition, the battery leasing enterprise can handle the deplete battery, leaving no polluting issue and make it easy to develop the green 4R battery system (resale, reuse, refabricate, recycle).

2.2 Ownership functions analysis

Under the new business model, the industrial chain

is totally different from that of convention al vehicle. It is compose of battery OEM, vehicle OEM, power supplier (third party) and customers. The vehicle OEM sales the EV without battery (soled with battery being option) to customers. The third party purchases batteries in stock leasing to customers, providing service and developing charging network, etc. The battery OEM, vehicle OEM and the third party negotiate the interface standards and designing specifications. The details are showed in figure 3

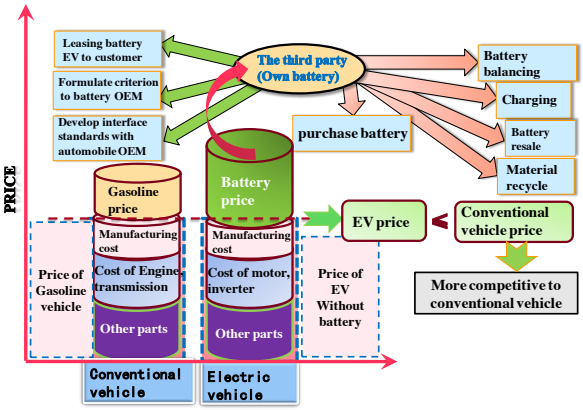


Figure 3: The conception of leasing battery business model

Based on the new business model, there are two rules to make EV's superiority to conventional vehicle in that the operating cost of an electric vehicle is much lower than that of a petrol vehicle, and the EV sale price is somewhat lower than that of the conventional vehicle.

3. New business model analysis

3.1 Assumptions

Take A0 class electric vehicle as example to analyze the economics of the new business model. The vehicle parameters are as following: EV curb mass is 1,200kg, battery capacity is 12kWh with cycle life of 1000. The range is 100km by once fully charging.

3.2 Operating rules

The operating cost of EV includes two parts: the cost of battery depreciation and the cost of electricity. However, that of CV is only petrol consumed cost. The cost benefit of EV is comparative to conventional vehicle, so it is determined by factors like petrol price, battery cost, battery performance(especial cycle life), and other factors such as battery resale places much effect on the EV operating cost during its lifecycle. To ensure EV more competitive to CV, the following rules must be complied with:

(1) The price of EV without battery is lower than that of the CV;

(2) The operating of EV is much cheaper than that of CV.

$$D = C_{EV} - C_{CV} \quad (1)$$

Operating cost of EV can be described as

$$C_{EV} = C_{elec} + C_{dep} - A \quad (2)$$

The equivalent cost of electricity can be described as

$$C_{elec} = \frac{\delta . E_{price}}{R} \quad (3)$$

The equivalent battery depreciation can be described as

$$C_{dep} = 1000 \frac{\delta . C_{bat}}{R . L_{cycle}} \quad (4)$$

Substitute formulas (3) and (4) it can be attained

$$C_{EV} = \frac{\delta . E_{price}}{R} + 1000 \frac{\delta . C_{bat}}{R . L_{cycle}} \quad (5)$$

CV operating cost per km can be described as

$$C_{CV} = \frac{\mu . P_{price}}{100} \quad (6)$$

So the EV and CV operating cost can be described a:

$$D = \frac{\delta . E_{price}}{R} + 1000 \frac{\delta . C_{bat}}{R . L_{cycle}} - \frac{\mu . P_{price}}{100} - A \quad (7)$$

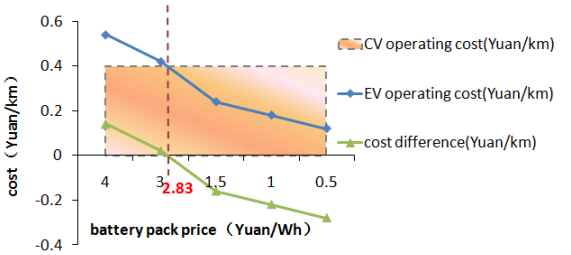
C_{EV} -operating cost of EV, Yuan/km;

C_{dep} -battery depreciation cost,Yuan/.km;
C_{elec} -cost of electricity, Yuan/kWh;
δ -Capacity of EV battery,kWh;
R -electric driving range of once charging, km;
C_{bat} -specific cost of battery, Yuan/Wh;
μ -fuel consumption of 100km, L/100km;
P_{price} -price of petrol, Yuan/L;
A -other influence factors, such as secondary sale bonus, carbon tax, battery performance improvement because of maintaining service by the energy service company, etc.

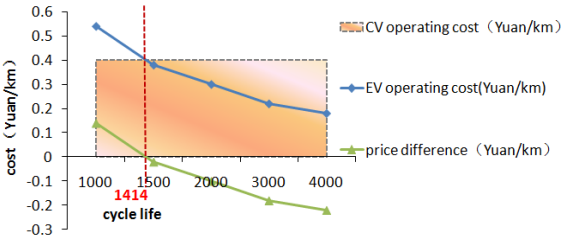
3.3 Opportunities of EV energy service party

3.3.1 Battery performance influence

It assumes that the price of petrol is comparative stable, the operating cost difference between EV and CV is mainly influenced by the level of battery technologies, such as cycle life, cost, etc. The battery's improvement will determine if the EV energy service providing enterprise will make profit. Based on the method of forecasting, profit balance point of EV energy service enterprise depending on the battery technologies is shown as Fig 4.



(a)



(b)

Figure 4: The single factor effect of battery

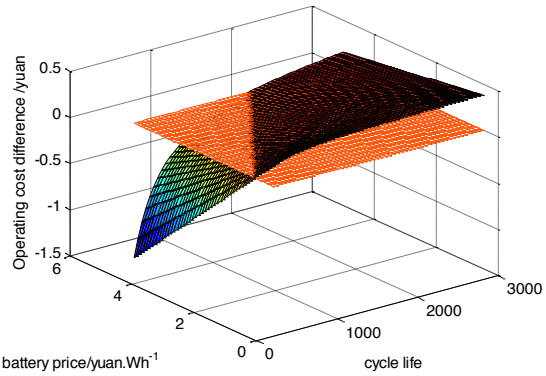


Figure 5: Coupled factors effect of power battery

From Figure 4, it can be seen that for A0 class EV even if the cost of battery is no lower than that of present, when its cycle life is 1414 the EV energy service providing company will begin make profit. Similarly, when the battery cost is only 2.83 that will happen. Targets above will be reached before 2015 according to China's electric vehicle technologies roadmap for 2020[10]. Moreover, the battery leasing will act as main driving force to accelerate the battery large scale production, so the cost will drop sharply.

3.3.2 Petrol price influence

It is known that the crude oil is limited and its price will definitely increasing in the long run. From the Figure 6, we can see the price of gasoline in Beijing have been increasing stable overall [11]. With the petrol price rising, the comparative advantages of EV to CV will increasingly significant.

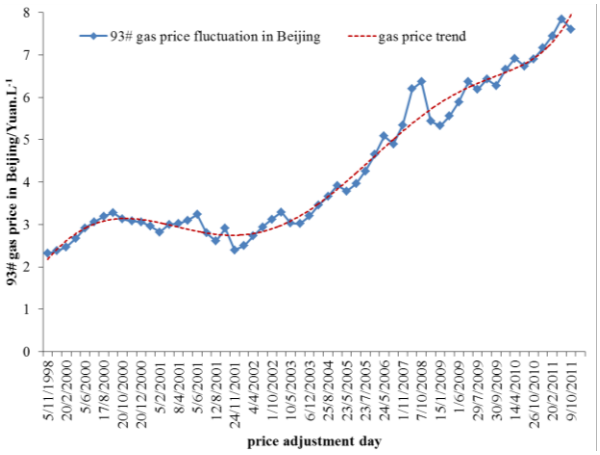


Figure 6: Gasoline price fluctuation of China

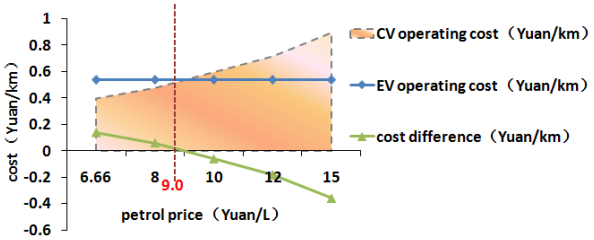


Figure 7: Gasoline price influence on the break-even point

From the Figure 7, it can be seen that if the petrol price increases to 9.0Yuan/L. if taking the carbon tax on petrol vehicle into consideration, in short term that point will be reached.

3.3.3 Electricity price influence

To encouraging adopting of EV, many countries and cities provide cheap electricity, even for free. Much lower electricity cost maybe leads to lower EV operating cost.

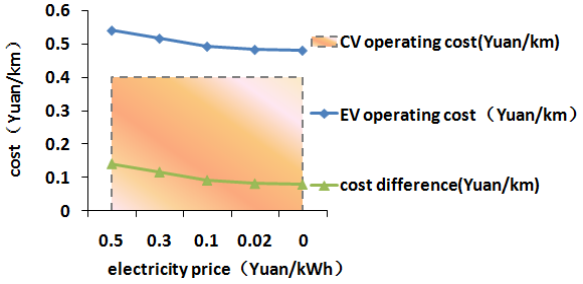


Figure 8: Influence on the break-even point of electricity price

From Figure 8 it can be seen that the electricity cost plays less importance in influencing the EV value chain. Even if EV be provided with charging for free, it cannot lead to profit balance for EV energy providing company (the third party).

3.3.4 Battery secondary profit influence

When the capacity EV battery dropped to lower than 80% it cannot work, but it can be used in other field, such as UPS, boat and stable energy storage for grid. The battery leasing company can sale after service battery to these industries to gain resale profit.

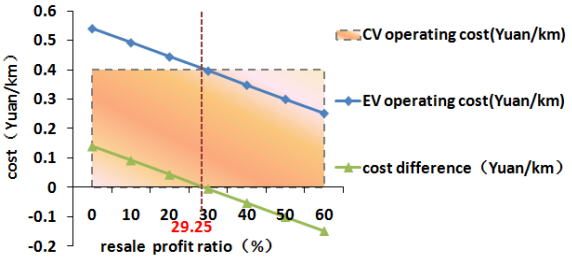


Figure 9: Influence on the break-even point of battery resale profit

From the Figure 9 it can be seen that battery secondary profit will impact the EV value chain greatly. If battery resale profit ratio is 29.25%, the battery leasing company will begin positive earning.

4 Vehicle model priorities

Under new business model characteristic as battery leasing, the large scale EV marked will be open. But it will not be the solution for all kinds of EVs. Base the on the same analyzing method as mentioned above, comparison of adopting A class EV and A0 class EV with new business model is shown in tab1.

Table 1: Analysis of the third party profit influencing factors

parameters	A0	A
cycle life	1414	2326
specific cost, Yuan.Wh^{-1}	2.83	1.72
petrol price, Yuan.L^{-1}	9.0	14.4
resale profit rate, %	29.25	57

From comparison above, it can be concluded that in initial stage of EV mass adoption small size EV easier to realize industrialization and should be taken precedence.

5. Conclusions

By comprehensive calculation and analysis, it can be concluded:

(1) The provided innovative EV business model is crucial to lead the battery large scale production resulting in the battery cost dropping sharply.
(2) The rates of adoption are driven by the low purchase price and operating costs of electric cars with battery leasing. The estimates include the cost of installing charging and battery switching infrastructure to extend the range of electric vehicles. The battery leasing business model is suitable for first generation EV mass penetration in China.
(3) The small size EV is optimal to the larger EV product to commercialize with new business model.
(4) From the results above, it can be see that electricity price places the least influence on break-even Point and other factors.
(5) The leasing battery enterprise will required state subsidy in EV introduction stage, and with the business model combined with smart charging net, the EV marked will increase rapidly, correspondingly, battery price decreasing greatly, moreover, taking the EV used battery resale profit into account, the third party will make profit and expending by itself without any subsidy.
In all, based on the present EV technologies, the innovative EV business model is feasible and makes pure EVs economically competitive with conventionally-powered vehicles and foster the first large scale EV market in China.

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