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Preliminary Assessment of EV Commercial Feasibility for Pilot Projects in Taiwan

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Abstract

Electric Vehicle has been an international trend so various industries try to evaluate EV cost and commercial viability to get into this market. This study lists each cost parameter that may affect companies' acceptability of market transference from traditional fuel vehicle to Electric Vehicle (EV). Three types of cost parameters are included and they transferable costs, fixed cost, and variable cost. Those cost parameters are environment construction, battery residual value, vehicle maintenance cost, vehicle price without battery, battery price, credit interest, oil market price, electricity market price, battery technology and so on. Here cabin cruiser of official rental type from Taiwan EV pilot projects is an example to compare with the same vehicle type of the fuel vehicle. This study attempts to construct a cost analysis model of the commercial viability. This model will identify the possible break-even point to be the reference for business preliminary measurement based on the pilot projects in Taiwan and provide the suggestion how to shorter the investment time from the analysis result.

keyword: EV(electric vehicle), cost analysis, commercial feasibility

1. Introduction

Since April 30, 2010, Taiwan government has approved "Intelligent Electric Vehicle Development Strategies and Action Plan", declared "Guidelines of Intelligent e-Cars Piloting Program", and established "intelligent e-Car Promotion Office". Many relative industries, academic communities, and research centers participated into this filed. Not only the advanced technology but also the promotions on market are needed for EV popularization.

Seen by the public information, many countries also actively promote the EV demonstration and on the progress towards the popularization through expending charging construction. For example, a number of pilot projects in Taiwan had established until 2012, such as "Rent-an-EV to tour Taipei" program and "Dream Biological Green Transportation Plan" in Taichung. In 2013, a new program named "i3 Travel" on the Sun Moon Lake National Scenic Area in Nantou. In these cases, traveling rental type is in Taipei and Nantou, but official rental type in Taichung. Some cities and companies are continuously researching different operating models and applying for demonstration. From these pilot projects in Taiwan, the main operating models are the official rental for government agencies and short-distance travel for visitors.

Preliminarily commercial feasibility is the subject of this study. The initial cost and possible affective factors are included to evaluate the break-even time as the analysis resources for this industry. Meanwhile, variable parameters are also taken into

account, including the fuel cost with fluctuations in the international and domestic markets. This research can be divided into three parts. Firstly, it has comprehensive review for the environmental costs, including oil market price, electricity market price, tax rates etc. Secondly, it takes cabin cruiser of official rental type from Taiwan EV pilot projects as an example to evaluate the total expenditure under the setting scenarios. Finally, it is the comparison of both fuel vehicle and EV to come out the analysis result of annual cost difference and break-even point. The research helps the companies to organize their resource as early as possible to gain niche market and have higher investment willingness. Here the subject focuses on 1201-1800cc of cylinder displacement volume. Control group B fuel vehicle is adopted to compare the treatment group A EV to establish this cost analysis model.

2. Literature review

The most concern for vehicle industry or relative components industry they are going to EV market is the commercial benefits. How do they enter this field? What is the most suitable business model? How can they get profits in the shortest time? There are a lot of research organizations who are doing studies of EV business model. An example is the study of operating cost analysis for commercial fleet. It displays commercial fleet is more predictable, compared to the general EV used by the public. The commercial fleet can be index in the pilot market by strategy of "lower total costs, environmental protection, and the corporate image". Also it points out the government is very important at the initial development phase and recommends the government to increase the investment attraction and reduce entrance costs.

3. Models and methods

This study is to establish the cost analysis model at pre-commercial phase so the vehicle industry can estimate their possible expense in EV market. In terms of vehicle operators, they wonder whether to enter the EV market, and concern most the commercial interests and the break-even time. Based on these points of view, the research makes below framework for commercial feasibility assessment, shown in Figure 1. The model can be divided into four parts respectively, establishment of usage scenarios and cost parameters, cost analysis model, and result with suggestion.

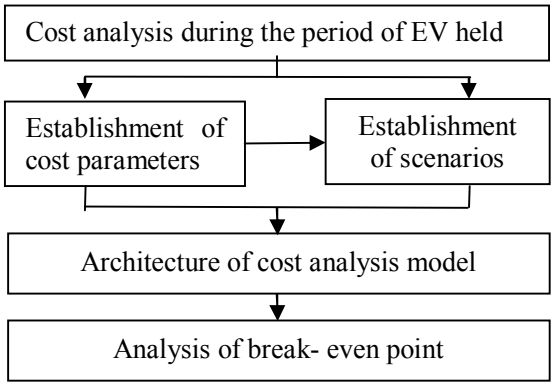

Figure1 Research framework

3.1 Cost parameters

In order to establish the cost analysis model, it needs to assume relative cost parameters ahead. Hereby table 1 as an expression of the parameter relations with their effects to the analysis result.

Table1: Relevant cost parameters

Associated costs	Effective factors	Explanation
Transferable costs	• Commodity tax • License tax • Fuel tax • Subsidy policy	When the government provides subsidies such as taxes free, total cost of EV implement will be reduced.
Fixed costs	• Environmental Construction costs • Battery residual value • Maintenance costs • Vehicle Price without battery • Battery price • Credit interest	Once companies get into the EV field, the cost is occurred.
Variable costs	• Oil market price • Electricity market price • Battery technology	Cost may be influenced by the external environment, such as international trends, and improved technology

The power supply of EV is battery, not as engine with cylinder volume for fuel vehicle, therefore the Ministry of Finance sets the comparison table to charge excise and license tax accordingly. Judging from this table, 1201 ~ 1800cc engine displacement of fuel vehicles B corresponds to 83.1-182HP of EV motor.

Table 2: Comparison table of EV horsepower and cylinder displacement of fuel vehicle.

Cylinder displacement (cc)	Motor horsepower (HP)
500 below	38HP below（38.6PS below）
501-600	38.1-56HP（38.7-56.8PS）
601-1200	56.1-83HP（56.9-84.2PS）
1201-1800	83.1-182HP（84.3-184.7PS）
1801-2400	182.1-262HP（184.8-265.9PS）
2401-3000	262.1-322HP（266-326.8PS）
3001 above	322.1.HP above（326.9PS above）

3.1.1 Excise

There are two numerical ranges for excise, divided by cylinder displacement at 2000cc. In order to increase the buying incentive and develop EV vehicle industry, the Executive Yuan, the Ministry of Finance, has provided exemption of excise and license tax for 3 years since January 28, 2011. That is the first phase and next phase is to review whether to extend exemption of excise before this comprehensive promotion period, 2014 to 2016.

Table3: Excise comparison table of EV horsepower and cylinder displacement of fuel vehicle

Type of vehicle	Fuel vehicle/ Cylinder volume	EV/ Horsepower	Tax
small Passenger Vehicle	over 2000cc	208.8 inch hp above; or 211.9 metric hp above	30%
	below 2000cc	208.7 inch hp above; or 211.8 metric hp above	25%

For example, EV A is mass production internationally at the numerical range below 2000cc of cylinder volume. That is to say the excise is 25%. If the selling price is US$63,000 in Taiwan, this preferential policy will offer buyers cost saving of US$18,900each.

3.1.2 License tax and Fuel tax

The amendment of license tax policy took effect on January 6, 2012 so local governments are authorized within three years for license tax exemption. This amendment encourages local governments and industries to apply demonstration project. So far the top 5 cities and over 12 counties including off-shore islands have announced the policy preference of license tax.

Because there is zero carbon emissions, governments will not charge fuel tax. Compared to the fuel vehicle with 1201-1800cc of engine displacement, EV has tax relief of license tax and fuel tax both, US$397 totally.

Table4: Numerical table of license tax and fuel tax for fuel vehicles

Cylinder displacement	License tax (USD)	Fuel tax (USD)	Subtotal/ yearly
500cc below	$54	$72	$126
501-600cc	$72	$96	$168
601-1200cc	$144	$144	$288
1201-1800cc	$237	$160	$397
1801-2400cc	$374	$207	$581
2401-3000cc	$507	$240	$747
3001-3600cc	$941	$288	$1,229
3601-4200cc	$941	$327	$1,268
4201-4800cc	$1,539	$374	$1,913
4801-5400cc	$1,539	$406	$1,945
5401-6000cc	$2,323	$436	$2,759
6001-6600cc	$2,323	$465	$2,788
6601-7200cc	$3,900	$497	$4,397
7201-7800cc	$3,900	$524	$4,424
7801-8400cc	$5,040	$524	$5,564

The price fluctuation of oil and electricity has significant impacts on consumer's adoption and EV market popularity.

3.1.3 Oil market price

Taiwan is the oil importing country, and domestic oil price is adjusted weekly in accordance with the floating oil price formula. This formula adopts weekly average price of international crude oil indicators (70% of Dubai +30% Brent, 7D3B) and 80% fluctuation of exchange rate to get the fluctuation range. The international oil price will

also change due to the volume of output and government policies.
Official website "Petroleum price of information management and analysis system" from the Bureau of Energy, Ministry of Economic Affairs provides the inquiry and analysis functions. People can find the related oil information through the basic messages to calculate the price fluctuation. According to the domestic historical data of unleaded gasoline 95, its retail price in 2012 is nearly US$1.13/liter and has average annual increase of 5% during the period from 2000 to 2012.

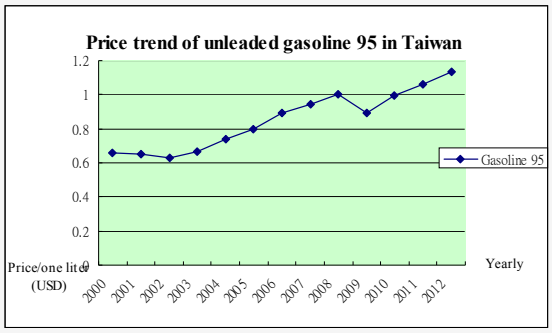

Figure 2: Oil price trend in Taiwan

3.1.4 Fuel consumption

Auto Energy website provides interactive inquiry of fuel consumption through the basic settings, such as oil price, estimated kilometers of driving annually, driving ratio in city or at highway, plus car brand, type and year of manufacture. The daily fuel consumption can infer monthly and annual fuel costs for comparison with similar EV type. General fuel consumption of sedan is average 10km/L or more. Here set this number as conservative value of fuel vehicle B.

3.1.5 Electricity price

Oil and electricity price is the trade-off relationship for the development of EV or fuel vehicle. Electricity price is relative to EV charging cost and was increased on June 10, 2012 so that people are more concerned about this issue. Most of corporations choose electricity rate of two-stage time-of-use and the average electricity price is about US$0.115/kwh. If the working time is in the evening largely, they can consider switching to the three-stage time-of -use rate. EV electricity consumption is around 0.125 degrees per kilometer and then it can come out electricity costs per year to compare with annual fuel costs.

Table 5: Electricity rate table

Two-stage Time-of-Use electricity rate (USD/kwh)		High voltage		Ultra-high voltage	
		Summer	Others	Summer	Others
Monday-Friday	Peak	0.118	0.114	0.116	0.112
	Off-Peak	0.058	0.054	0.056	0.053
Saturday	Self-Peak time	0.083	0.08	0.078	0.074
	Off-Peak	0.058	0.054	0.056	0.053
Sunday & off-peak days	Off-Peak	0.058	0.054	0.056	0.053

3.1.6 Credit Interests

Fuel vehicle companies will evaluate their investments in expanding into EV market. EV selling price is obviously higher than that of fuel vehicle due to the key factor, battery. Battery price is one third of whole vehicle, and even a half. Once companies decide to start this new market in original capital size, they need to have additional influx of capital and one way is from bank loan. Corporate lending rate may be different due to the degree of business dealings with the bank and the capital. Here interest rate is 3% per annum to know the additional interest expense.

3.1.7 Environmental Construction costs

The purpose of demonstration projects is to promote the popularity of EV and charging stations, therefore EV can get rid of limited cruising endurance. Each country has its charging connector standards and the standards are on the way of integration globally. Taiwan targets to announce DC specification standard at the end of 2013 or 2014. Now local governments and charger companies are developing AC charging points mostly. In Taichung, 49 chargers are built cumulatively and the cost is reference due to the subsidy of demonstration projects.

Table 6: Environmental construction costs of current chargers without smart device

Chargers	Amount (thousands, USD)	Development rate
DC (fast charge)	27~33	10%
AC (slow charge)	2~3.5	90%

3.1.8 Maintenance costs

Drive motor of EV has fewer mechanical parts, compared to the internal combustion engine of the fuel vehicle. The features are simple structure, no oil system and lower failure rate so the maintenance cost should be relative lower. It can release from oil and gear oil change, hence its mechanism has less depreciation than the traditional fuel vehicle at the same operational use time. With reference to industry interview information, the maintenance cost of commercial vehicle is about US$167 per month and this study assumes that.

Table 7: Comparison table of maintenance costs yearly between EV and fuel vehicle

Types	EV	Fuel vehicle
Amount (UTD)	1,000	2,000

3.1.9 Battery Lifecycle:

As time goes by, EV battery quality is reducing and it will lead to lower conversion efficiency and power output. Now lithium battery is developing trend and it has the features of stronger durability and slow consumption. After 2,000 times of charge-discharge, the performance is degraded to 80% of original battery. General lifecycle is 4 to 5 years and should be extended in future through advanced battery technology and energy management system. Battery life will directly affect the overall recovery time. In order to maintain the best use of time, this assumes that battery pack has to be replaced at the 6th year. The cost of an extra battery pack is added then and amortized into years of use.

3.1.10 Battery residual value

A battery of fuel vehicle can be recycled with residual value after replacement from fuel vehicles. In the same way, a battery of EV has residual value and that value is one method to decrease the company' expense. Residual value is various due to the bard and operation condition. CAP, a British company of vehicle residual value assessment, shows that EV still remains 40% value of selling price after driving 30,000 kilometers. Therefore, the residual rate is estimated 20% of battery price to evaluate the re-used value after replacement.

3.1.11 Battery Technology price

The largest cost of total components in EV price is the battery pack. Once the battery technology is improved to decrease the cost, EV price will be possible lower flexibly. In 2009, the cost per kilowatt-hour of battery pack was higher than US$ 1,000 and has been reduced year by year. The main reason of battery price decline currently is oversupply. If the battery price would go down, in combination with higher EV production and sales, they will help for EV price decline steadily. According to the Pike Research, EV battery cost per kilowatt-hour of battery pack is US$689 in the first quarter of 2012 and is expected to between US$200-500/kWh in 2020. Moreover, Bloomberg, an American financial channel, reports the estimated cost per kilowatt-hour in 2030 may drop to US$150, under this downward tendency without inflation. The study figures out the likely cost of battery pack in future years.

Table 8: Cost trend of battery pack

Year	Cost of battery pack (kilowatt-hour, USD)
2009	1200
2010	1000
2011	800
2012	689
2020 (Forecast)	200~500
2030 (Forecast)	150

3.1.12 Vehicle Price without battery

EV design is often imitated or modified from fuel vehicle so the vehicle size is very close. Below is the assumptive selling price likely of two types of vehicles.

Table 9: Comparison table of selling price between EV and fuel vehicle

Types & Price (thousands, USD)	Whole (a=b+c)	Vehicle without Battery (b)	Battery (c)
EV (A)	63	40	23
Fuel vehicle (B)	23	N.A.	N.A.

Selling price of EV(a) is mainly composed from two parts, vehicle without battery(b) and battery(c). The predictive EV price is calculated yearly, according to the estimated declining trend of battery pack cost.

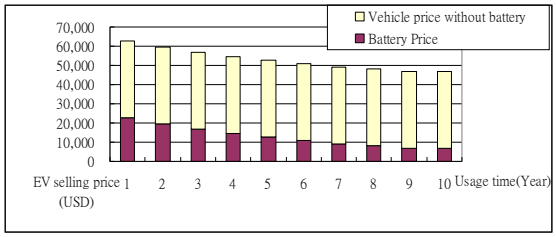

Figure 3: Ratio of vehicle without battery(b) and battery(c) in EV(a=b+c) Selling price

3.2 Usage Scenario

From the feedback of demonstration projects, the running distance of official rental type in Taichung is added up to 494,952km till first quarter of 2013. The features of cabin cruiser are patrolling continuously and easier to be predicted its operation state but data in motion is confidential and limited to be released. This study builds up some default values of electric vehicles and fuel vehicle meanwhile accordingly. These two kinds of vehicles will be in the same condition to explore the cost difference between.

Table 10 Default setting for EV and fuel vehicles

Setting items	Default value
Driving kilometer each time per vehicle	100
Working days per vehicle monthly	28
Vehicle quantity	10
Optimal life cycle per vehicle/year	10

4. Cost and Benefit analysis

Those cost parameters are placed into cost analysis model to get the initial EV cost by spreadsheets. The analysis results in vehicle acquisition mode have two factors they should be considered. Firstly, due to the finite oil energy, oil price is rising yearly so the price of fuel vehicle will be following higher; Secondly, the present price of EV is much higher than that of fuel vehicle, therefore EV has higher amortized cost at first few years.

Overall view of the annual accumulative cost from the below figure, it obviously can be seen that cost of EV is slowly increased, but that of fuel vehicle has risen sharply. In the ninth year, two accumulative cost curves of EV and fuel vehicle have a crossing point. The reason of fuel vehicle cost higher than EV cost is that energy usage cost of EV is significantly lower than that of fuel vehicle; hereafter EV has cost advantage then continuously.

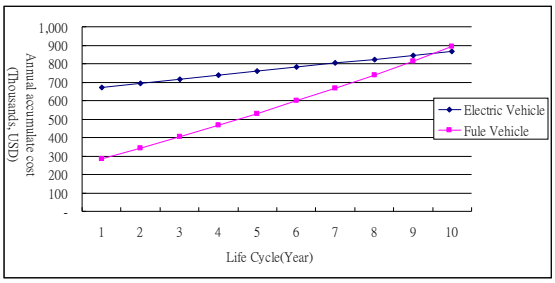

Figure 4: Accumulative cost analysis chart of EV and fuel vehicle

Taiwan government provides subsidies and free commodity tax for parts of energy infrastructure and the vehicle without battery for three years. If this subsidy policy is included in the cost analysis model, the break-even time can be shortened from over ninth years to four years. The special offer can accelerate the industry into EV market and stimulate EV market expansion.

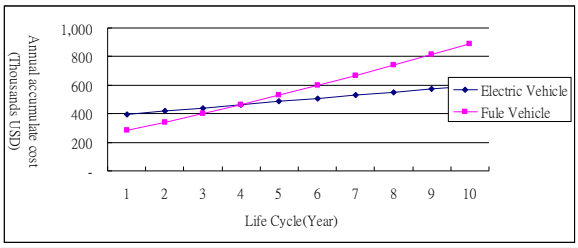

Figure 5: Accumulative cost analysis chart of EV and fuel vehicle with Taiwan government subsidy policy

5. Conclusion

This study attempts to construct a cost analysis model of the commercial viability and takes one EV of Taiwan pilot project as an example. According to the estimation of accumulated cost, the industry needs development time with capital input for nine and a half years, but it can be reduced to four years with subsidies from the government. For enterprises, they still have to invest continuous capital for these four years so the original financial structure may be the impacted.

From this analysis, we can find some results to provide the suggestions. Firstly, most vehicle industry is conservative thinking for entering into EV market and keeps watching, unless the government grants subsidy or strengthen the environment building of charging stations.

Secondly, battery price is the key issue which affects the vehicle price hugely. As the battery

technology has the breakthrough development, EV price is following decrease. Companies and government can give more resource on this filed at the same time.
Finally, the running distance and vehicle working days of cabin cruiser are also important feasibility factors in this business model. Once the number can not reach this setting of usage scenario, it will be harder for cost and benefit analysis and find the present result. Taichung government can implement the patrol function completely to promote the EV popularity.
In conclusion, this study points out the visible profitability of business feasibility. The cost assessment is proposed to be the reference of leading into EV market for recent industries, after collecting cost on the view of economics, technology and user scenarios. Expect higher EV popularity and a breakthrough development of battery technology is revealed, consequently the pre-commercial feasibility of EV market at initial period will be greatly improved.

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