Electric Vehicles Project Post Evaluating Based on AHP

Liping Wang [a], Junchao Yang [b]

School of Economics and Management, North China Electric Power University, Beijing 102206, China

[a]lpwang@ncepu.edu.cn, [b]gs_windboy@126.com

Abstract

Electric vehicles project promoting is a new effective way to reduce the gas emissions pollutions. It is necessary to evaluate the past electric vehicles project for manufacturers to promote the electric vehicles better. This paper constructs a post evaluation index system form project application process, economic benefit, project influence and project sustainable development ability four aspects. Combine with the index system, a case study is given and the weights of the indexes are calculated by AHP method, the results shows the proposed model is feasibility and effective for the electric vehicles project post evaluation. Finally, some suggestions and countermeasures are given.

Keywords

electric vehicle, post evaluation, AHP.

1. Introduction

With the china's economic development, the living level of the people is continuous increasing, and the car exhaust emissions become one of the main air pollution sources, which give a great threat of the people's health, especially in big cities such as Beijing, Shanghai. In China, the private car's ownership is exceed one hundred billion [1], although the car industry gives an important function of China's economic, the exhaust pollution is also a big problem, which should be solved at now. As early as 1998, the World Health Organization held a big polluted cities rankings in the world, and eight of the world's most serious air pollution cities in top 10 were coming from China. Recently, Beijing is always appearing the Haze phenomenon in the ending of 2015, and the car exhaust emissions is one of the major source. With the increasing of the private cars numbers, the controlling the private cars ownership is an important problem, Therefore, the reform and management of the car's industry is very essential.

Currently, the world attach great importance to the development of the electric Vehicles industry. American electric vehicle industry mainly be supported from both management and policy incentives, the details conclude the establishment of a rational development of electric vehicle technology standards, the maximum fuel caps and establish some tax, R&D polices to promote the development of the electric vehicle industry[2,3]. France, Japan, South Korea also have introduced policies to support research and development of electric vehicle-related technology [4,5]. In China, Ministry of Industry and Information Technology promulgate "energy-saving and new energy automotive industry development plan (2012-2020)", which clearly pointed that the pure electric vehicles is a development direction of new energy vehicles of the future. The electric vehicles will become the future of the emerging strategic of the car industries. In this background, it is necessary to construct an index system of post evaluation of the electric vehicles project, and evaluate the past existing electric vehicle project, and find the electric car project differences in the expectation and result for the future electric car project building for reference.

2. Construction of electric vehicles project post evaluating index system

According to the theory of post-evaluation, the role of the post-evaluation is to examine the difference between the expected and the project completion in order to give the summary. In general, the post-evaluation is from four aspects, which are the implement the project process, economic, project impact and the sustainable development. Therefore, this paper also create the post-evaluation index system from the four aspects.

2.1 Implement the project process

Electric vehicles project implementation process can be divided into decision related information analysis, primary basis of the project and the electric vehicles' design and the technical parameters including battery technology, motor technology and related ancillary facilities. Currently, the battery and motor technology are the two main factors restricting the development of pure electric vehicles. The reason is that the battery life will caused Mileage of the running of the electric vehicles, the strong battery life will enhance the demand of the pure electric vehicle. Electric vehicle motor is the key impact of speed capability, the main factors affect the success of the electric car project.

2.2 Economic evaluation.

Economic evaluation of the electric vehicles project means assess the project from an economic perspective, the main factors includes the purchase price, energy prices, the relevant insurance premiums, vehicle maintenance cost and so on. In addition, the electric vehicle support of government subsidies for electric car project will give greater economic impact of electric vehicles.

2.3 Project impact evaluation

The main impact of the electric vehicles project is on environmental protection and conservation for reducing the fossil energy, which is mainly to avoid the emissions generated by the traditional fuel vehicles. Otherwise, the electric vehicles will promote the related industries, such as rechargeable batteries, motor technology, industrial technology, charging pile stimulating economic development. It will affect the development of the national economy indirectly.

2.4 Sustainable development ability

For the sustainable development of the electric vehicle project, the consumer preference is one of the most important impact indicators, which can be measured by electric vehicle's ownership. In addition, R&D investment of electric vehicles is the basis input of the electric vehicle's industry sustainable development.

From the above analysis, the electric vehicles project post evaluating index system is built as Table 1.

3. An empirical analysis based on Analytic Hierarchy Process

3.1 The introduction of Analytic Hierarchy Process

Analytic Hierarchy Process(AHP), proposed by professor T.L.Saaty, is a effectively method to solve the complex and ambiguous correlations problem. It uses experts experience to translate qualitative into quantitative analysis. When people are facing complex selection problems, they often decompose the problem into individual elements, divide them into groups according to the dominance relation to build the hierarchical structure, and determine the relative importance of these elements by comparing one to one in each hierarchy. Then combined with the judgment of decision makers to obtain the final decision, selection or judgment. The steps of AHP to determine the index weights are as follow[6]:

(1) Establish pairwise comparisons judgment matrix

First of all, establish the judgment matrix U by comparing the elements one to one, in the matrix U, u_{ij} is the importance proportion criteria of U_i and U_j for X. And the importance proportion criteria can be gotten from Table 2.

Table 1. The electric vehicles project post evaluating index system

Object level	Criterion level	Index level
post evaluation index system of Electric Vehicles Project	application process(B1)	primary basis(C11)
		Battery technology design level(C12)
		Motor technology design level(C13)
		related ancillary facilities design level(C14)
		Speed level(C15)
	economic benefit(B2)	Purchase price(C21)
		Charging electric price(C22)
		Insurance cost(C23)
		Maintenance cost(C24)
	project influence(B3)	Air environmental protection(C31)
		Related industries influence(C32)
	sustainable development ability(B4)	electric vehicle's ownership(C41)
		R&D investment level(C42)

Table 2. The meanings of judgment matrix proportion criteria

Proportion criteria	Meanings
1	The importance are equal between these two elements
3	One of the two elements is slightly more important than the other
5	One is more important than the other
7	One is much more important than the other
9	One is extremely more important than the other

Then, calculate the index weights in each hierarchy. The steps are as follows:

1) Calculate the product M_i of each line elements of judgment matrix

$$M_i = \prod_{j=1}^{n} x_{ij}, i = 1,2, \cdots \mathrm{n} \quad (1)$$

2) Calculate the n-th root of M_i

$$W_i = \sqrt[n]{M_i} \quad (2)$$

3) Normalize the vector $W = [W_1, W_2, \cdots, W_n]^T$

$$W_i = \frac{W_i}{\sum_{j=1}^{n} W_j} \quad (3)$$

Then, the vector $W = [W_1, W_2, \cdots, W_n]^T$ changes to be the eigenvector (weights).

However, it is impossible to ensure the absolute consistency when the elements are comparing with each other. Thus, to keep the reliability of Analytic Hierarchy Process, the consistency of the judgments must be checked after normalizing. And the checking steps are as follows:

(2) Calculate random consistency index CI

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{4}$$

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{\sum_{j=1}^{n} x_{ij} W_j}{W_i} \tag{5}$$

In the formulas, n is the judgment matrix order, while λ_{max} is the largest eigenvalue of the judgment matrix.

(3) Calculate consistency ratio CR

$$CR = \frac{CI}{RI} \tag{6}$$

In the formulas, RI is an average random consistency index, which can be queried. The consistency of the judgment matrix can be accepted when $CR < 0.1$. If not, the appropriate modification of the judgment matrix is needed until the consistency can be accepted.

Thus, the relative weights of indexes of each hierarchy can be obtained with the above steps. And then, based on every index's position in the overall index system, the weights times the weights of the next hierarchy can output the weights p_j of indexes of the last hierarchy.

(4) Define a candidate set $X = \{x_1, x_2, \cdots x_i, \cdots x_n\}$, and an evaluation score matrix R. the final comprehensive evaluation result can be calculate by $W*R$.

3.2 Empirical analysis

From the post evaluation index systems, it can be clearly seen that many of the indicators are difficult quantitative. It should use some method to transfer the experts experience into quantitative numbers at first, the rules of the transferring are as follows: For each quantitative indicators, using experts experience to give one of the level of the level set {best, better, good, worse, worst}, and change the language into the score range [90,100],(80,90),(70,80],(60,70] and [0,60) respectively, then using the average scores as the indicator scores.

3.3 Case study

According to the above AHP method and the description of indicators scores, two electric vehicle project E150ev and E6 are evaluated as follows:

Firstly, the weights of the criterion level indicators are calculated by AHP method in Table 3.

Table 3. The pairwise comparisons matrix and weights of criterion level

Indexes	B1	B2	B3	B4	Weights
application process(B1)	1	1/5	1/3	1/5	0.072
economic benefit(B2)	5	1	2	1	0.368
project influence(B3)	3	1/2	1	1/2	0.192
sustainable development ability(B4)	5	1	2	1	0.368

According to the above index calculation result of criterion level, the weights of these four aspects are slightly different with each other. The weights of economic benefit and sustainable development ability are bigger than other indicators, and the smallest one is the application process.

Similarly, the final weights calculation can be gotten, and a case results are shown in Table 4. As can be seen from the final index, the weight of the electric car project in the purchase price is bigger than others, it is advising that the electric vehicle project should be noted on the vehicle's purchase price and the level of project financing supports, and according to the scores of the indicators of the E150ev and BYD E6 comparative evaluation, E150ev is slightly better than BYD E6, the reason is the scores of purchase price and the market share of electric cars of E150ev are higher than BYD E6, and the weights of the tow indicators are also large.

Table 4. The comparison and evaluation results of E150ev and BYD E6

Indicators	Final weights	E150ev	BYD E6
primary basis(C11)	0.024	80	85
Battery technology design level(C12)	0.008	75	90
Motor technology design level(C13)	0.008	75	82
related ancillary facilities design level(C14)	0.024	80	80
Speed level(C15)	0.008	75	80
Purchase price(C21)	0.192	87	79
Charging electric price(C22)	0.031	80	80
Insurance cost(C23)	0.056	80	75
Maintenance cost(C24)	0.088	75	80
Air environmental protection(C31)	0.096	80	80
Related industries influence(C32)	0.096	80	82
electric vehicle’s ownership(C41)	0.12	85	80
R&D investment level(C42)	0.249	78	80
Total	1	80.89	79.94

4. Conclusion

Electric vehicle industry is still in its infancy stage, and it need to continue to promote the development of the industry to achieve the energy conservation from fossil energy to electric energy. Therefore, the electric vehicle project post evaluation will give some lessons learned from the past project to better promote the development of electric vehicles. After analyzing the results of the proposed evaluation index system and comparable results, the important thing to promote the electric project is the consumer price and electric vehicles project basis in decision-making level. In addition, in terms of the macro level, the government and grid management should increase efforts to promote electric vehicles and electric vehicle charging convenience in order to provide guarantee success for electric vehicle’s projects.

References

[1] B. Yang L.F Wang. Research on Power-Charging Demand of Large-Scale Electric Vehicles and Its Impacting Factors, diangong jishu xuebao,Vol. 2(2013),22-27.

[2] J. Axsen, K.S. Kurani, Early U.S. market for plug-in hybrid electric vehicles: Anticipating consumer recharge potential and design priorities. Transportation Research Record: Journal of the Transportation Research Board, Vol.2139 (2009) No 1, p. 64-72.

[3] Andersen, H. Poul, Mathews, A. John, R. Morten, Integrating Private Transport into Renewable Energy Policy: The Strategy of Creating Intelligent Recharging Grids for Electric Vehicles. Energy Policy, Vol.37 (2009) No 7, p. 2481-2486.

[4] B. Stephen, P. David, S. Paul, Electric Vehicles: The Role and Importance of Standards in an Emerging. Market Energy Policy, Vol.38 (2009) No 7, p. 3797-3806.

[5] A. Pushker, Kharecha, F. Charles, Kutscher, E. James, et al. Options for Near-Term Phaseout of CO2 Emissions from Coal Use in the United States, Environmental Science & Techno1ogy, Vol.44 (2010) No 11, p. 4050-4062.
[6] T.L. Saaty: The analytic hierarchy process. (McGraw-Hill Book Co, New York 1980), p.1-7.