Research on evaluation system and method of EVs' development trend

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Abstract. Electric vehicles (EVs) are an significant instrument for clean substitution in China's transportation due to their low-carbon emission characteristics. Analyzing EVs' development trend requires developing an evaluation system. This paper proposes an evaluation index system that takes into account the perspective of policy supported, technological development, market scale, supporting construction, and business ecology. Then, according to the Analytic Hierarchy Process (AHP), evaluation methods are provided. Finally, taking Jiangsu Province as an example, the EVs' development trend in Jiangsu Province is evaluated.

Keywords: EVs; low-carbon characteristics; development trend evaluation system; evaluation method;

1 INTRODUCTION

EVs are a tool to combat climate change and advance green transportation development [1]. The "New Energy Vehicle Industry Development Plan (2021-2035)" published by the General Office of the State Council suggested that by 2025, sales of EVs will make up 20% of all auto sales, demonstrating the trend toward large-scale development of EVs. In order to identify the weak points in the development of EVs, it is crucial to evaluate the trajectory of EV development.

Currently, there is literature on the assessment and investigation of the development trend of EVs. In terms of institutions, the "2020 New Energy Vehicle Development Index Report" [2] was published by Qingbo Research Institute. In this report, the development trends of EVs in China and the United States are compared and analyzed from four dimensions including value, market, technology and policy at the macro level; and from five dimensions including technology driving force, policy driving force, market driving force, capital driving force and environmental protection driving force at the macro level; and from the capital capacity, benefit capacity, management capacity, technical capacity and service capacity at the micro level. The "Consumption Index and Prosperity Index of New Energy Vehicles" [3] published by the China Electric Vehicle Association of 100 People and Autocar constructed the new energy vehicle

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industry index from the two dimensions including "consumption index" and "industry prosperity index", which are primarily focused on the sensory quality, safety, performance design, and cost-performance ratio of newly listed vehicles every three months. In terms of literature, the majority literature studied EVs' development trend focus on analyzing the impact of EVs' development on the environment and economy, and proposing development paths and strategies [4-8]. Some literature also evaluated the willingness to buy electric vehicles [9-11], the effect of financial subsidy policy [12-13], and the factors affecting EVs' development [14-15].

In conclusion, there is no a systematic, comprehensive and accurate evaluation system evaluating the development situation of EVs, which makes it challenging to correctly direct the healthy growth of the electric vehicle industry. Therefore, this paper proposes an evaluation system for EVs' development trend from policy support, technological development, market scale, supporting construction, and business ecology. Subsequently, the development trend results of EVs in Jiangsu are analyzed as a case.

2 EVS DEVELOPMENT SITUATION EVALUATION SYSTEM

EVs' development involves policies, technologies, markets, basic infrastructure, and business, which is an organic integration of industrial chain, energy chain, technology chain, and etc. Therefore, the evaluation system of EVs' development trend should integrate policy support, technological development, market scale, supporting construction, and business ecology. This paper proposes an evaluation system for the EVs' development trend as shown in the following Figure 1.

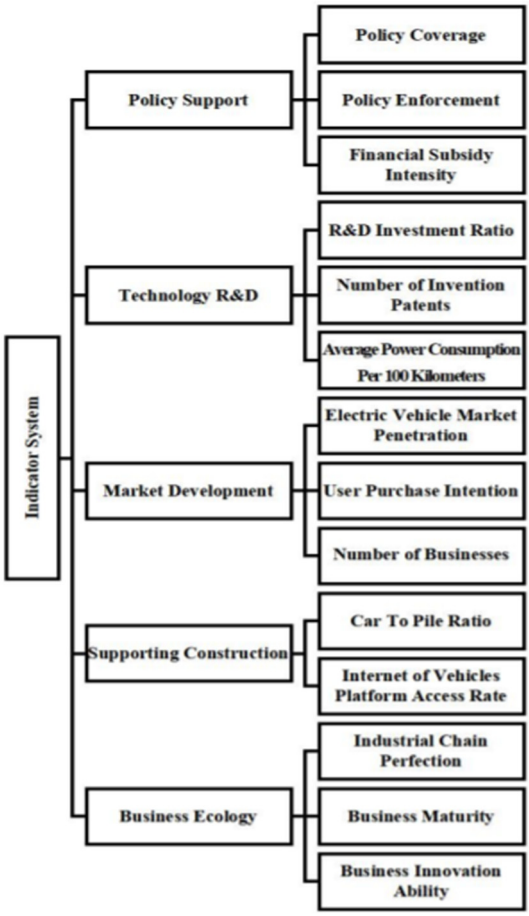

Fig. 1. Evaluation system of EVs' development trend

3 EVALUATION METHOD OF EVS' DEVELOPMENT TREND

The evaluation indicators for EVs' development trend are consisted qualitative indicators and quantitative indicators. The value of the qualitative indicators will be determined according to the expert scoring method, such as policy coverage. As for quantitative indicators, the indicator will be standardized, such as the number of enterprises, vehicle pile ratio. The specific methods are as follows:

$$x_i' = \frac{x_{i-}x_{min}}{x_{max-}x_{min}} * 100 \quad (1)$$

The evaluation method of EVs' development trend needs to clarify the weight of each index. AHP [16] can clarify the weight of each index, and construct a multi-level

and multi-objective evaluation method. Therefore, this paper mainly adopts the AHP to calculate the weight of each index value, and the method of the judgment matrix is shown in table 1.

Table 1. Importance level and evaluation value ofjudgment matrix

Importance Rank	A_{ij}	Rank	A_{ij}
The same	*1*	*Very Strong*	*9*
Slightly	*3*	*Between the above two*	*2,4,6,8*
Strong	*5*	*Contrary to the above*	*1,1/2,....1/9*
Stronger	*7*		

4 EVALUATION CASE OF EVS' DEVELOPMENT TREND IN JIANGSU PROVINCE

4.1 Index value of EVs' development trend in Jiangsu Province

Jiangsu Province is a major automobile province in China. The information of EVs' development trend in Jiangsu Province comes from government policies, enterprise industry reports, online materials, and consumer experience. The index values of EVs' development in Jiangsu province are shown as Table 2.

Table 2. The index values of EVs' development in Jiangsu Province

First-level Indicators	Index	value	Normalized Value
Policy Support	*Policy Coverage*	*100*	*100*
	Policy Enforcement	*70*	*70*
	Financial Subsidy Intensity	*80*	*80*
Technology R&D	*R&D Investment Ratio*	*1.2%*	*80*
	Number of Invention Patents	*16700*	*100*
	Average Power Consumption Per 100 Kilometers	*15kWh/ Per 100 Kilometers*	*80*
Market Development	*Electric Vehicle Market Penetration*	*25%*	*70*
	User Purchase Intention	*50%*	*80*
	Number of Businesses	*42.3thousand*	*90*
Supporting Construction	*Car To Pile Ratio*	*2:1*	*85*
	Internet of Vehicles Platform Access Rate	*40%*	*80*
Business Ecology	*Industrial Chain Perfection*	*70*	*90*
	Business Maturity	*80*	*80*
	Business Innovation Ability	*9%*	*90*

4.2 Evaluation result of EVs' Development trend in Jiangsu Province

According to the table 1, the scoring results of the first-level indicators are as follows.

$$A_1 = \begin{bmatrix} 1, & 0.33, & 0.33, & 0.33, & 0.33 \\ 3, & 1, & 2, & 0.33, & 0.33, \\ 3, & 0.5, & 1, & 0.5, & 0.33 \\ 3, & 3, & 2 & 1, & 0.33 \\ 3, & 3, & 3 & 3 & 1, \end{bmatrix} \quad (2)$$

According to the AHP, the consistency results of the judgment matrix are as follows:

$$\lambda_{max} = 5.337; CI = \frac{\lambda_{max}-n}{n-1} = 0.0944; CR = \frac{CI}{RI} = 0.0843 < 0.1 \quad (3)$$

It can be seen from the above that the consistency of the judgment matrix is less than 0.1, and the judgment matrix has a high consistency. Therefore, the weight of the first-level indicator is:

$$W_1 = [0.07, 0.16, 0.12, 0.24, 0.41] \quad (4)$$

According to the above method, the analysis results of the secondary indicators are as follows:

$$W_{11} = [0.2, 0.4, 0.4]$$
$$W_{12} = [0.7, 0.2, 0.1]$$
$$W_{13} = [0.2, 0.6, 0.2]$$
$$W_{14} = [0.5, 0.5]$$
$$W_{15} = [0.2, 0.3, 0.5]$$

The evaluation results of the EVs' development trend in Jiangsu Province are shown in Table 3.

Table 3. Evaluation results of EVs' development situation in Jiangsu Province

Evaluation Object	Total Score	First-level Indicators/ Weights	Score	Index/Weight	Normalized Value
The Development Trend of EVs	*84.39*	*Policy Support / 0.07*	*84*	*Policy Coverage / 0.2*	*100*
				Policy Enforcement / 0.4	*80*
				Financial Subsidy Intensity / 0.4	*80*
		Technology R&D / 0.16	*84*	*R&D Investment Ratio / 0.7*	*80*
				Number of Invention Patents / 0.2	*100*
				Average Power Consumption Per 100 Kilometers / 0.1	*80*
		Market Development / 0.12	*80*	*Electric Vehicle Market Penetration / 0.2*	*70*
				User Purchase Intention / 0.6	*80*
				Number of Businesses / 0.2	*90*
		Supporting Construction / 0.24	*82.5*	*Car To Pile Ratio / 0.5*	*85*
				Internet of Vehicles Platform Access Rate / 0.5	*80*
		Business Ecology/ 0.41	*87*	*Industrial Chain Perfection / 0.2*	*90*
				Business Maturity / 0.3	*80*
				Business Innovation Ability / 0.5	*90*

5 CONCLUSION

On the basis of synthesizing the existing evaluation system of EVs, this paper integrates the related research results, proposes an evaluation indicator system for EVs' development trend from the perspective of policy support, technology development, market scale, supporting construction, and business ecology. Then, the evaluation methods are given, and analyzes EVs' development trend in Jiangsu Province. The evaluation result shows that EVs' development trend in Jiangsu Province is positive, but that there is still potential for improvement in R&D spending, EV penetration, and EV platform availability. The study will further develop the assessment index system in the future and broaden the use of the evaluation technique to more cities.

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