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ORIGINAL ARTICLE

Policy Evaluation and Optimization of Hydrogen Industry Based on PMC Index Model

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Abstract
With the transformation of global energy structure and the increasingly severe problem of climate change, hydrogen as a clean and efficient energy carrier, how to formulate effective policies to guide and support the development of hydrogen industry has attracted extensive attention from scholars. In this paper, 13 hydrogen industry policies of first-tier cities are taken as objects. Firstly, text mining technology is used to analyze the policies quantitatively through high-frequency word capture and co-occurrence semantic network analysis of policy texts. Then PMC index model and its index system suitable for hydrogen industry policy evaluation are constructed to realize quantitative evaluation of the policies to be evaluated, and then the advantages and disadvantages of each policy are identified, and corresponding optimization suggestions are put forward. The results show that most hydrogen energy policies can effectively support the development of hydrogen energy industry, but there are deficiencies in policy continuity, target clarity and object applicability. Therefore, policy shortcomings should be further improved and optimized in detail.
Keywords: PMC index model; hydrogen energy industry; text mining; high-frequency word capture; semantic network analysis.

Introduction

In March 2022, the Medium and Long-term Plan for the Development of Hydrogen Energy Industry jointly issued by the National Development and Reform Commission and the National Energy Administration (2021-2035) mentioned the need to build a clean, low-carbon, safe and efficient energy system and promote the highquality development of hydrogen energy industry. Hydrogen has become an important part of the future national energy system. According to the survey, in the first half of 2024 alone, ministries and commissions of the state issued more than 33 policies related to promoting the development of hydrogen energy industry, and local governments issued more than 140 policies related to hydrogen energy industry, including 54 special policies for hydrogen energy and 91 policies related to hydrogen energy. It can be seen that the development of hydrogen energy industry cannot be separated from the guidance and support of policies. If we need to know the actual effect of these policies and whether there is room for optimization, then it is important to study what aspects the government should improve the effectiveness of policies through the data in relevant policies, so as to provide theoretical and methodological support for the scientific formulation and effective implementation of hydrogen industry policies, and to further promote the healthy development of China's hydrogen industry.

1 Literature Review

With the transformation of global energy structure and the increasingly severe problem of climate change, hydrogen, as a clean and efficient energy carrier, can play a key role in many fields such as electricity, transportation and industry, which has aroused scholars' thinking on the sustainable and healthy development of hydrogen industry.

However, the development of hydrogen energy industry needs not only technological innovation, but also policy guidance and support. Therefore, in-depth analysis and evaluation of existing hydrogen energy policies has become an important research direction. In view of domestic policies, Li Juan et al. [1] analyzed the characteristics of hydrogen energy industry policies in China in detail from policy high-frequency vocabulary, policy issuing organization and policy geographical distribution through analyzing hydrogen energy industry policies in various provinces, autonomous regions and cities across the country; Tang Yun et al. [2] systematically analyzed and compared the hydrogen energy technology research basis in Beijing, Shanghai, Guangzhou and Wuhan by using text mining technology, and studied the evolution path of hydrogen energy industry policies in China and the four cities [3] [4].

In view of foreign policies, Huang Sheng et al. [5] put forward the development path of China's hydrogen industry chain based on China's national conditions on the premise of comparing and analyzing the development of hydrogen industry in the United States, EU, Japan and China in recent years; Yang Jie et al. [6] sorted out the international definitions and standards on green hydrogen, and the green hydrogen policies of major countries and China [7].

Based on the summary of existing literatures and published hydrogen energy policies, this paper selects the policy text data related to hydrogen energy industry in representative first-tier cities to sort out and process, and uses PMC index model to quantitatively analyze the quality of hydrogen energy policies, in order to provide scientific decision support and policy suggestions for promoting the healthy development of hydrogen energy industry and promote the development of hydrogen energy industry towards high quality [8].

2 **Research Ideas and Methods**

This paper takes the hydrogen industry policy issued by first-tier cities as the research object, analyzes the high-frequency words of policy text by ROSTCM6, and considers them as key points in policy evaluation.

PMC (Policy Modeling Consistency) index model, whose core idea originates from Omnia Mobilis hypothesis, is a quantitative tool for policy evaluation [9]. The core of this model lies in using text mining method to process policy documents, which can not only analyze the internal heterogeneity and quality level of a certain policy in multiple dimensions, but also visually display the advantages and disadvantages of each dimension of the policy through PMC surface graph, so as to identify the advantages and disadvantages of each policy and put forward optimization suggestions [10]. The basic implementation steps of the PMC index model are as follows:

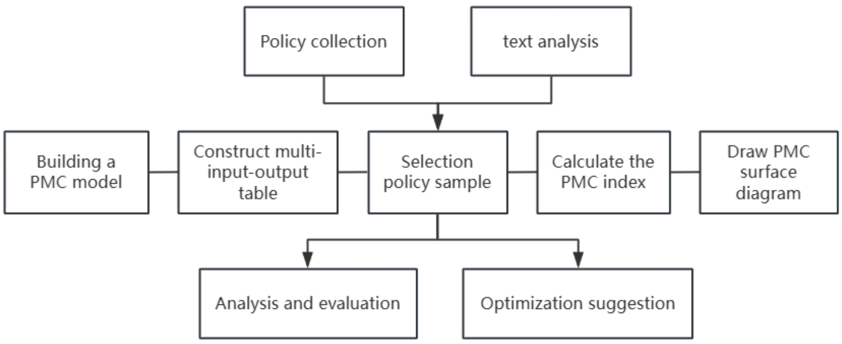

Figure 1 PMC index model implementation steps

2.1 Sample Selection

In order to ensure the accuracy of the sample, this paper selects the hydrogen energy industry policies of the first-tier and new-tier cities in China as the sample data, and uses the data source of Peking University Magic Weapon Database to collect data samples. The key words of "hydrogen energy" and "hydrogen industry" are used to retrieve information, and the following criteria are used to filter the policy texts:

(1) Take various local regulations as the retrieval objects, and the policy effectiveness level includes

laws, administrative regulations and departmental regulations;

(2) Because this paper discusses the current policy support tendency, the screened policies and regulations are the latest laws and regulations in their validity period, which makes the policy analysis more timely.

Based on the above criteria, and Naive Bayes-a text classification method based on Bayes theorem, used to calculate the probability that a document belongs to a certain category when classifying text, the Naive Bayes formula is known:

$$P(c|d) = P(d|c) \times \frac{P(c)}{P(d)} \#(1)$$

where P(c|d) denotes the probability that document d belongs to category c; P(d|c) denotes the probability that document d appears under the condition of category c; P(c) denotes the probability of category c; P(d) denotes the probability of document d.

Among the new first-tier cities, Chongqing, Hangzhou, Xi'an, Nanjing, Dongguan, Hefei and Foshan did not retrieve policies related to hydrogen energy industry, while Beijing, Shanghai and Wuhan retrieved two policies for hydrogen energy industry development, and finally determined thirteen policy samples.

2.2 Policy Text Analysis

2.2.1 Keyword Analysis

Rostcm6 is used to make statistics on high-frequency words of policies, eliminate meaningless words, and retain the words with the top 15 frequencies. Among them, the calculation formula related to word frequency (TF, Term Frequency):

$$TF(t) = n(t)n\#(2)$$

TF(t) denotes the frequency of word t in the document, n(t) denotes the number of times word t appears in the document, and n denotes the total number of words in the document.

2.2.2 Semantic Network Analysis

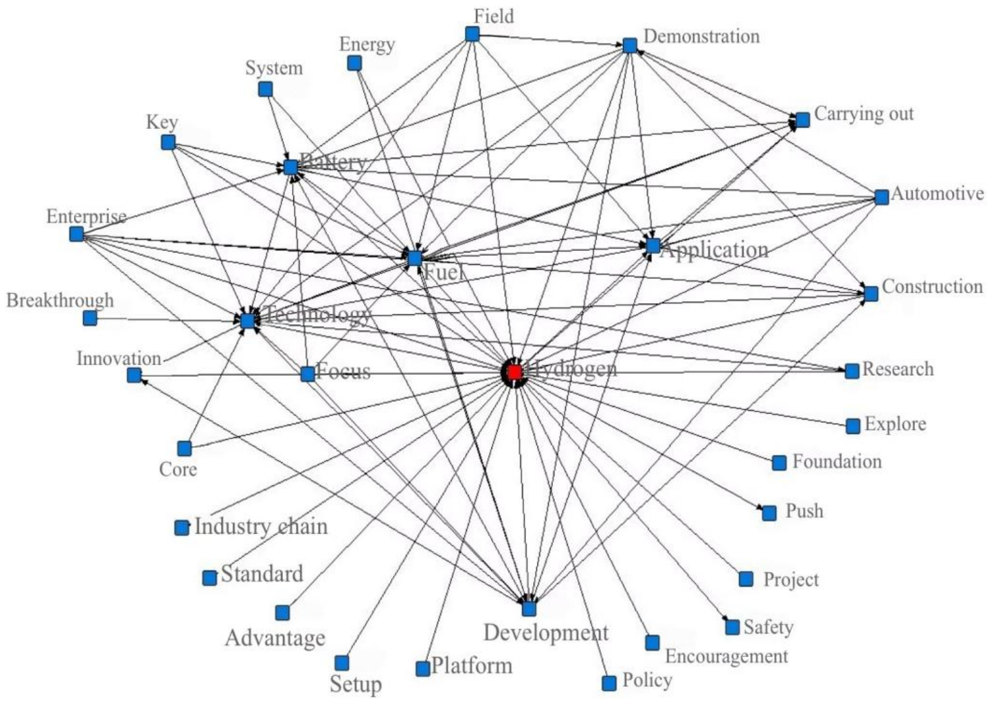

Figure 2 Social Network Mapping of High Frequency Words in Hydrogen Energy Industrial Policy Texts

2.3 PMC Index Model Establishment

2.3.1 Variable Classification and Parameter Setting

In order to ensure the scientific rationality of the policy evaluation index system, based on the index system constructed by Estrada, referring to PMC research literature and relevant analysis of hydrogen energy industry policy, combining with the high-frequency words and word system network obtained above, this paper finally sets up a policy evaluation index system including 9 first-level evaluation systems and 43 second-level indicators. When assigning values, binary assignment method is adopted to ensure that the weights of all secondary indicators are equal, i.e. if the policy includes this variable, the assignment is 1, and if it does not, it is 0. The indicator names and evaluation criteria.

2.3.2 Constructing Multiple Input Output Tables

Based on PMC policy evaluation model constructed in this paper and 13 selected hydrogen industry policy texts, a multi-input-output table is constructed, which is the key step to realize PMC index model quantitative evaluation, including input and output parameters of each policy, in order to record and quantify various resource inputs and expected results of each policy in detail.

2.3.3 PMC Index Calculations

Formula (3) indicates that all secondary variables obey two-point distribution;XR indicates integer; Formula (4) indicates that all secondary variables are assigned 0 or 1; Formula (5) indicates the method of calculating primary variables from secondary variables: the score of primary variables is the ratio of the total score of secondary variables corresponding to the primary variable to the number of secondary variables; Formula (6) indicates the calculation method of PMC index: i.e. the sum of scores of all primary variables of policies.

$$\mathrm{X} \in \mathrm{N}: \{0,1\} \# (3)$$

$$\mathrm{X} = \mathrm{XR}: \{0,1\} \# (4)$$

$$\mathrm{X_i} = \left(\sum_{j=1}^{n} \frac{\mathrm{X_{i:j}}}{n} \right), i = 1,2, \ldots, 9 \# (5)$$

i= primary variable, j= secondary variable, n= number of secondary variables

$$\mathrm{PMC} = \sum_{i=1}^{9} X_i = \mathrm{X_1} + \mathrm{X_2} + \cdots + \mathrm{X_9} \# (6)$$

According to Formula (3) and Formula (4), assign values to the secondary indicators according to the variables set in Table 3 against the policy content, calculate the primary indicator values of each policy according to Formula (5), and calculate the PMC index value of the policy to be evaluated according to Formula (6). (Take P1 as an example)(a in the following formula represents the secondary variable)

$$\mathrm{X1} = \sum_{a=1}^{6} \frac{\mathrm{X_{1a}}}{6} = \frac{0+1+1+1+1+1}{6} = 0.83$$

$$\mathrm{X2} = \sum_{a=1}^{4} \frac{\mathrm{X_{2a}}}{4} = \frac{0+1+1+0}{4} = 0.50$$

$$\mathrm{X3} = \sum_{a=1}^{4} \frac{\mathrm{X_{3a}}}{4} = \frac{1+1+1+1}{4} = 1.00$$

$$\mathrm{X4} = \sum_{a=1}^{4} \frac{\mathrm{X_{4a}}}{4} = \frac{1+0+1+1}{4} = 0.75$$

$$\mathrm{X5} = \sum_{a=1}^{3} \frac{\mathrm{X_{5a}}}{3} = \frac{1+0+0}{3} = 0.33$$

$$\mathrm{X6} = \sum_{a=1}^{3} \frac{\mathrm{X_{6a}}}{3} = \frac{0+1+1}{3} = 0.67$$

$$\mathrm{X7} = \sum_{a=1}^{11} \frac{\mathrm{X_{7a}}}{11} = \frac{1+1+1+1+0+1+0+0+0+1+1}{11} = 0.64$$

$$\mathrm{X8} = \sum_{a=1}^{4} \frac{\mathrm{X_{8a}}}{4} = \frac{1+1+1+1}{4} = 1.00$$

$$\mathrm{X9} = \sum_{a=1}^{4} \frac{\mathrm{X_{9a}}}{4} = \frac{0+1+1+0}{4} = 0.50$$

$$\mathrm{PMC} = X_1 + X_2 + \cdots + X_9 = 0.83 + 0.5 + 1 + 0.75 + 0.33 + 0.67 + 0.64 + 1 + 0.5 = 6.22$$

2.3.4 Policy Evaluation

The calculation results of PMC index represent the consistency level of policy evaluation model. According to the evaluation grade standard of Mario Arturo Estrada [9], the specific values calculated by PMC index are divided into the following four grades, as shown in Table :

PMC index	Estimation
0~3.9	Poor
4.0~5.9	Acceptable
6.0~7.9	Excellent
8.0~9.0	Perfect

Ranked the PMC index results from highest to lowest are as follows:

Ranking	Policy	Score
1	P4	8.50
2	P13	8.16
3	P9	7.67
4	P6	7.57
5	P3	7.41
6	P7	7.41
7	P5	7.33
8	P8	7.33
9	P11	7.17
10	P10	7.08
11	P2	7.08
12	P12	6.83
13	P1	6.22

2.3.5 Drawing PMC Surfaces

According to PMC index results, a matrix is established according to 3×3.

$$\mathrm{P1} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 0.75 & 0.33 & 0.67 \\ 0.64 & 1 & 0.5 \end{pmatrix} \quad \mathrm{P2} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 0.75 & 0.67 & 0.33 \\ 1 & 1 & 1 \end{pmatrix} \quad \mathrm{P3} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 0.5 & 1 & 0.67 \\ 0.91 & 1 & 1 \end{pmatrix}$$

$$\mathrm{P4} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 1 & 1 & 0.67 \\ 1 & 1 & 1 \end{pmatrix} \quad \mathrm{P5} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 0.75 & 0.67 & 0.67 \\ 0.91 & 1 & 1 \end{pmatrix} \quad \mathrm{P6} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 1 & 1 & 0.33 \\ 0.91 & 1 & 1 \end{pmatrix}$$

$$\mathrm{P7} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 0.5 & 1 & 0.67 \\ 0.91 & 1 & 1 \end{pmatrix} \quad \mathrm{P8} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 0.75 & 0.67 & 0.67 \\ 0.91 & 1 & 1 \end{pmatrix} \quad \mathrm{P9} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 1 & 0.67 & 0.67 \\ 1 & 1 & 1 \end{pmatrix}$$

$$\mathrm{P10} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 0.5 & 0.67 & 0.67 \\ 0.91 & 1 & 1 \end{pmatrix} \quad \mathrm{P11} = \begin{pmatrix} 0.83 & 0.5 & 1 \\ 0.5 & 0.67 & 0.67 \\ 1 & 1 & 1 \end{pmatrix} \quad \mathrm{P12} = \begin{pmatrix} 0.83 & 0.25 & 1 \\ 0.5 & 0.67 & 0.67 \\ 0.91 & 1 & 1 \end{pmatrix}$$

$$\mathrm{P13} = \begin{pmatrix} 0.83 & 1 & 1 \\ 0.75 & 1 & 0.67 \\ 0.91 & 1 & 1 \end{pmatrix}$$

PMC surface chart usually represents different evaluation indicators of policies through different dimensions of three-dimensional graphics. Different colors represent different index scores. The convex part indicates that the policy scores higher on the corresponding evaluation indicators, while the concave part indicates that the policy scores lower on the corresponding evaluation. PMC surface chart of these 13 policies is shown in Figure 3:

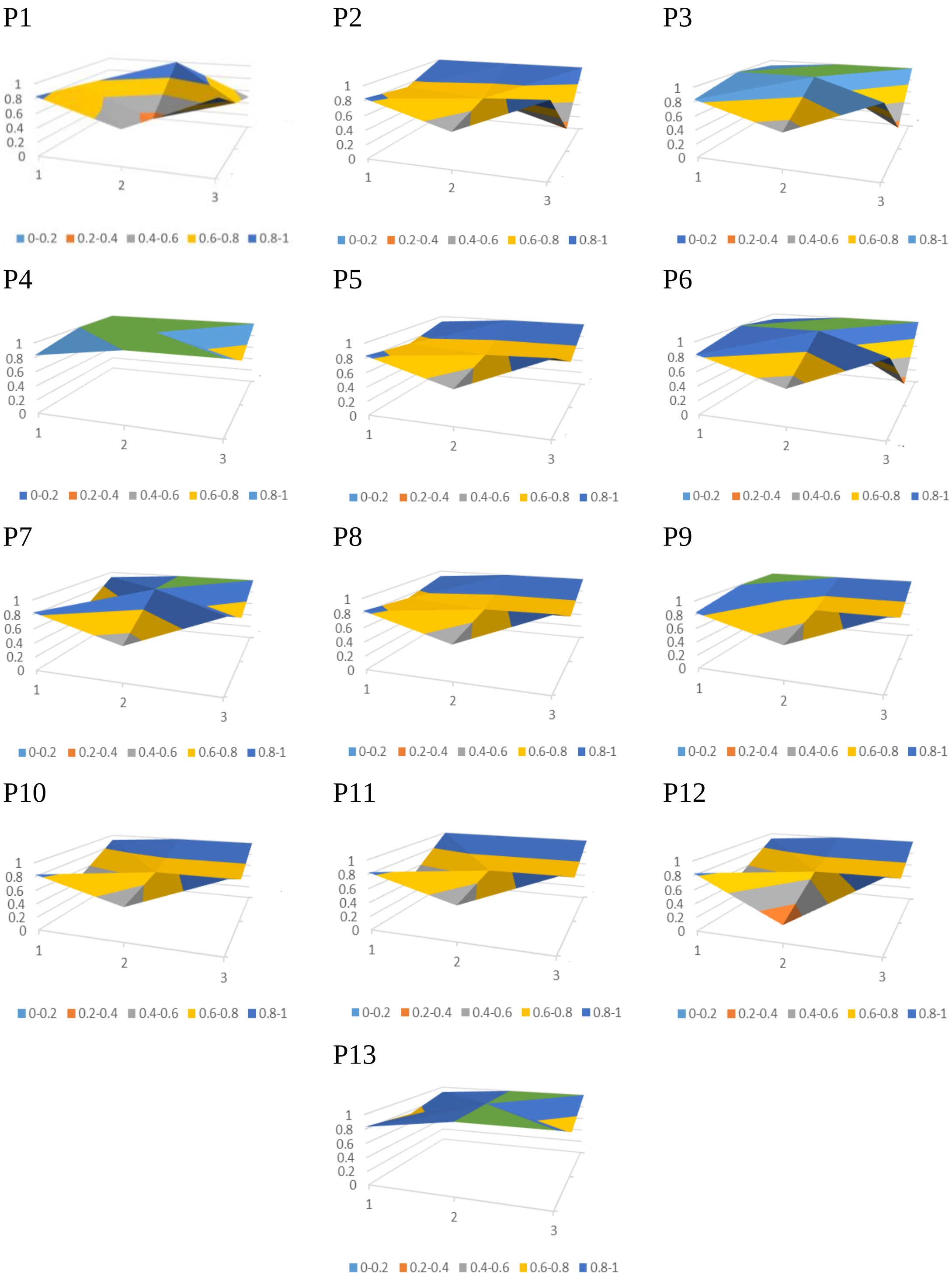

Figure 3 PMC Surface diagram

3. Conclusions and Recommendations

3.1 Conclusion

According to PMC index score, 13 policies are sorted as follows: P4>P13>8.0> P9>P6>P3=P7> P5=P8>P11>P10=P2>P12>P1>6.0. From the results, two policies are perfect, eleven policies are excellent, and there are no acceptable or bad policies, which indicates that the hydrogen energy industry development policies of China's first-tier cities are scientific and reasonable, and can promote the development of hydrogen energy well.

On the whole, all policies of X1 policy nature have high scores, indicating that the supporting and guiding role of policies is obvious;X3 policy function scores are very high, indicating that policies play a significant role in regulating and guiding the development of hydrogen energy industry; however, X2 policy effectiveness scores are low, indicating that the policy validity period is short and the medium-and long-term planning is lacking.

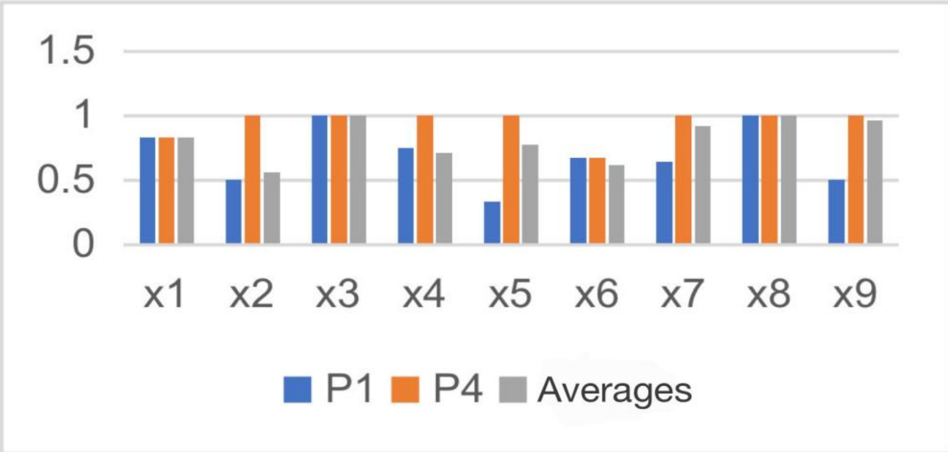

Figure 4 Comparison of scores across P1, P4 and 13 policy averages

As can be seen from Figure 4, the P4 policy score is 8.50, ranking the highest among policy scores. This policy focuses on Shanghai Lingang, an important area in my country. The policy design and goal achievement of this policy in a specific direction are very successful, which not only accurately identifies the key bottlenecks and core needs for the development of the hydrogen energy industry in the region, but also effectively promotes the solution of these problems and the satisfaction of needs through a series of innovative policies and measures. In addition, the development goals of hydrogen energy industry set by it are both concrete and feasible, and through clear timetable and road map, the implementation and effective implementation of various policies and measures are ensured.

P1 policy score 6.22, ranking lowest among policies, the scope of this policy is Beijing Daxing District. Although it gets high scores on policy function (X3) and policy evaluation (X8), the overall score is low due to low scores on policy perspective (X5) and policy receptor (X9). It shows that although the hydrogen energy policy of Daxing District is clearly implemented, it ignores the medium and long-term planning and the application scope of receptor in the development process.

3.2 Recommendation

Based on the above findings, the following policy recommendations are made:

In terms of precise positioning and policy design, we should fully understand regional characteristics and demand identification, such as the status quo of hydrogen industry, resource endowment, market demand and challenges, so as to ensure that policies can accurately match local characteristics and actual needs. In terms of laws and policy norms, it is necessary to establish and perfect the legal and regulatory framework of hydrogen energy industry, clarify the approval process, safety standards and environmental protection requirements of hydrogen energy projects, strengthen supervision and evaluation, establish effective supervision mechanism, implement whole-process supervision on hydrogen energy projects, and ensure that policies are implemented in place.

Further strengthen and improve the advantages of policies. In terms of top-level design and policy support, we will issue special policies for the development of hydrogen energy industry, establish a coordination mechanism for hydrogen energy industry, set up a leading group or coordination agency for hydrogen energy industry development, strengthen cross-department cooperation, and coordinate and solve major problems in industrial development. In terms of infrastructure construction and market promotion, expand hydrogen energy application scenarios, promote the wide application of hydrogen energy in transportation, industry, construction and other fields, strengthen hydrogen energy science popularization propaganda, improve public awareness and acceptance of hydrogen energy, and create a social atmosphere conducive to the development of hydrogen energy industry.

4. Acknowledgements

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Reference：

1. Juan Li, Juan Gong, Qiang Ren. Analysis of hydrogen energy industry policy situation in China's provinces, autonomous regions and cities and the inspiration for Shaanxi[J]. Science and Technology Innovation and Productivity,2024,45(06):49-51.
2. Yun Tang, Hongyang Wang, Fang Yue et al. A comparative study on the evolution of hydrogen energy industrial policies in Beijing, Shanghai, Guangzhou and Wuhan[J/OL]. World Science and Technology Research and Development,1-15.
3. Dongling Huang, Yuan Liu, Xiaoshuai Yuan et al. A study on data mining of China's hydrogen energy policy based on natural language processing technology[J]. Proceedings of the Chinese Academy of Sciences,2024,39(06):1032-1046.
4. Yidong Wang, Suyu Xu, Taibi He et al. Research on China's Hydrogen and Fuel Cell Industry Policy and Implications[J]. Natural Gas Industry,2024,44(05):136-145.
5. Sheng Huang, Zhenli Yang, Zhenyu LI. Path analysis of hydrogen industry chain development[J]. Chemical Progress, 2024, 43(02):882-893.
6. Jie Yang, Bo Chai, Yuanzhao Li. Research on the development policy of green hydrogen in foreign countries and the inspiration for China[J]. China Energy,2023,45(07):78-84.
7. Qingsheng Zhang, Xuesong Huang. Analysis of domestic and international hydrogen energy industry policies and technical economics[J]. Low Carbon Chemistry and Chemical Industry,2023,48(02):133-139.
8. Niall F. Policy design for green hydrogen[J]. Renewable and Sustainable Energy Reviews, 2023,178.
9. Arina B , Christine Q , Lukáš L , et al. The more the merrier? Actors and ideas in the evolution of German hydrogen policy discourse[J]. Energy Research & Social Science,2023,97.
10. Zhang, Q, Chen, WM, Ling, W. Policy optimization of hydrogen energy industry considering government policy preference in China. Sustainable Production and Consumption,2022(33):890-902.