Perspective of China's energy strategy from world trend based on a combined Fuzzy-Logarithmic and Fuzzy-TOPSIS method

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Abstract. The downward pressure of the world economy is increasing, with a rising populism tends and geopolitics turbulence. The emerging economy led by China turns into the main body of energy market increment. The global energy supply and demand pattern is undergoing profound changes, which makes energy strategy more and more important. Based on the evolution practice analysis of energy strategy in typical countries proposed by our team, several important paths of energy strategy in China are identified firstly. Meanwhile, a combined Fuzzy-Logarithmic and Fuzzy-TOPSIS method is proposed in this paper in order to rank the key points of energy strategy, especially considering the energy strategy issues are always complex and difficult to quantify. Finally, seven strategy paths are evaluated by priority, which are demanded-oriented reform, mitigating institutional mechanisms contradictions, energy technology breakthrough, global energy governance, energy enterprise synthesis strength improvement, energy finance system construction and integrated energy system construction. It is expected that the advice proposed in this paper is beneficial to our energy industry.

1. Introduction
Energy is the lifeblood industry of the country. Especially in recent years, the situation at home and abroad has become increasingly complex and geopolitical turmoil has been fierce. Under this background, major countries and regions have adjusted their medium and long-term energy development strategies in recent years in order to enhance national energy security, accelerate green transformation and support economic development. Accompanied by the enhancement of comprehensive national strength, China has become one of the most important influential participant in the global energy field. Therefore, it is necessary to study the international energy pattern in order to make a more scientific and reasonable strategic priority path.

The energy strategy of typical countries and regions are discussed by our team in China Energy News column called World Energy Winds more than half a year[1-4]. The global energy development is also widely analyzed such as energy consumption, technology innovation and so on[5-6]. Based on the worldwide energy environment, the key points of energy strategy in China are identified[7-8]. Meanwhile, researches are also focused on the priority rank method for energy strategy choices. A multi-criteria decision analysis approach is proposed for electricity supply sustainability and...
A modified fuzzy Topsis method and an integrated fuzzy VIKOR & AHP method are proposed for decision making in energy planning[10-11]. The rest of the paper consists of sections below. Section 2 provides an evolution practice of energy strategy in typical countries of the world. Section 3 gives some Initial discussion and suggestions on China's energy strategy in order to identify the important paths for energy strategy. The combined Fuzzy-Logarithmic and Fuzzy-Topsis method is proposed for strategy path priority ranking in Section 4. The results and discussion are provided in Section 5. Finally, the conclusion in this paper is summarized in section 6.

2. Evolution Practice of Energy Strategy in Typical Countries of the World

Our research team had opened a column "World Energy Trend" in China Energy Daily, eighteen papers were published for the energy strategy of typical countries. The diversity in the strategic pattern and path is briefly introduced below to find an energy strategy path classification.

Firstly, the lifeline of an energy country is the top priority of national security, internal affairs and diplomacy. Russia directly regards energy as the cornerstone of its economic development. Energy export has long been a critical strategic means for Russia to promote domestic economic growth, participate in the world economic system, maintain geopolitical influence and improve the political environment.

Secondly, Saudi Arabia influence international oil prices and global markets by means of output control, embargo and price increase in special periods with the aid of the platform OPEC. On this basis, Saudi Arabia obtains dominance in the Middle East and the Arab world. Similarly, OECD member countries joined the IEA of the International Energy Agency to effectively enhance their capacity to respond to potential oil crises by coordinating national energy policies and strategic oil reserves use.

Third, the most developed countries and regions in the world make much account of leading the energy financial system. The United States bound its financial with energy strategies, and fixed oil as the industrial lifeline to anchor the dollar, establishing the "oil-dollar-US Debt" system to export liquidity, transfer risks and gain benefits towards the world. The U.S. energy strategy has already surpassed the sight of economic interests and become an indispensable strategic weapon to control the world energy pattern and further exert its geopolitical influence.

Fourthly, Turkey, relying on the natural advantage of the Eurasian-African Continental Hub, has kept seeking its position as an energy hub and socialized between Europe, the United States and Russia. By this means, Turkey not only acquired energy resources for its rapid economic development, but also significantly promoted its international status and voice. Singapore draws support from the geographical advantages of the eastern entrance and exit of the Strait of Malacca, in order to flourish refining industry and oil import and export trade.

Fifthly, South Africa's "energy for all" characteristics can not only directly alleviate its energy shortage, energy discrimination and other issues, but also solve deep-seated social problems such as employment, education and talent system construction. Norway pays more attention to the sustainable development through efficient collaborative management in energy and finance, enterprises, industries and other fields.

3. Initial Discussion and Suggestions on China's Energy Strategy

Based on the viewpoints above, the developed countries in the world pay more attention to leading energy change and promoting economic recovery, while the emerging economies in Asia attach more significance to energy security and affordability of energy economy, while South America and Africa focus mainly on solving social problems. In recent years, green development, energy cost and other energy issues have turned into the core concerns of economic and social development in China. Energy strategy must be integrated into the overall development strategy of the country. It will have closer links with all sectors of society, all sectors of the industry and all market players, which consequently requires more unified coordination in strategic planning. Based on the worldwide energy
strategy discussed above, seven important paths are identified as figure 1, of which its corresponding priority are to be analyzed.

![Figure 1. Important paths identification of energy strategy](image)

4. The combined Fuzzy-Logarithmic and Fuzzy-Topsis method

In order to rank the key points of energy strategy, a combined Fuzzy-Logarithmic and Fuzzy-Topsis method is proposed in this paper. Because energy strategy issues are complex and difficult to quantify, they are often ambiguous and rely more on researchers’ judgments. The Fuzzy-Logarithmic weighting theory is applied in this paper to process the information of these indicators. Meanwhile, The Fuzzy-Topsis method provides a way to deal with uncertain, immeasurable problems under fuzzy environment. The method theory is proposed below.

4.1. Fuzzy-Logarithmic weighting approach

The fuzzy judgement matrix \( A \) shown as equation (1). \( d_{ij} \) denotes the relative importance of factor \( D_i \) compared to factor \( D_j \), \( l_{ij} \) and \( m_{ij} \) Respectively represent Lower and upper bounds of the triangular fuzzy values, \( u_{ij} \) is optimal value. Where \( l_{ij} = 1/u_{ji} \), \( u_{ij} = 1/l_{ji} \), \( m_{ij} = 1/m_{ji} \), \( 0 < l_{ij} \leq m_{ij} \leq u_{ij} \).

\[
\tilde{\mathbf{A}} = (\tilde{d}_{ij})_{n \times n} = \begin{bmatrix}
\tilde{d}_{11} & \tilde{d}_{12} & \cdots & \tilde{d}_{1n} \\
\tilde{d}_{21} & \tilde{d}_{22} & \cdots & \tilde{d}_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
\tilde{d}_{n1} & \tilde{d}_{n2} & \cdots & \tilde{d}_{nn}
\end{bmatrix} = \begin{bmatrix}
(l_{11}, m_{11}, u_{11}) & (l_{12}, m_{12}, u_{12}) & \cdots & (l_{1n}, m_{1n}, u_{1n}) \\
(l_{21}, m_{21}, u_{21}) & (l_{22}, m_{22}, u_{22}) & \cdots & (l_{2n}, m_{2n}, u_{2n}) \\
\vdots & \vdots & \ddots & \vdots \\
(l_{n1}, m_{n1}, u_{n1}) & (l_{n2}, m_{n2}, u_{n2}) & \cdots & (l_{nn}, m_{nn}, u_{nn})
\end{bmatrix}
\]

We suppose \( w_i \) as the weight of \( D_i \). Then the logarithm form of the fuzzy judgment matrix is as follows in equation (2):

\[
\mu_i \left( \ln \left( \frac{w_i'}{w_j'} \right) \right) = \begin{cases} 
\ln \left( \frac{w_i'}{w_j'} \right) - \ln l_{ij} & \text{if } \ln \left( \frac{w_i'}{w_j'} \right) \leq m_{ij} \\
\ln m_{ij} - \ln l_{ij} & \text{if } \ln \left( \frac{w_i'}{w_j'} \right) = m_{ij} \\
\ln u_{ij} - \ln l_{ij} & \text{if } \ln \left( \frac{w_i'}{w_j'} \right) \geq m_{ij}
\end{cases}
\]

As well, \( \mu_i(\ln(w_i'/w_j')) \) represents the degree of membership relatively. we set \( \lambda \) as minimum membership degree, then the fuzzy logarithm model can be expressed as equation (3):

\[
\min J = (1 - \lambda)^2 + M \times \sum_{i=1}^{n} \sum_{j=1}^{n} \left( \delta_{ij}^2 + \eta_{ij}^2 \right)
\]

\[
\begin{align*}
& x_i - x_j - \lambda \ln(m_{ij} / l_{ij}) + \delta_{ij} \geq \ln l_{ij} \\
& -x_i + x_j - \lambda \ln(u_{ij} / m_{ij}) + \eta_{ij} \geq \ln u_{ij} \\
& \lambda \geq 0, x_i \geq 0, \delta_{ij} \geq 0, \eta_{ij} \geq 0
\end{align*}
\]

In equation (3),According to the inequality, the optimal solution can be obtained, then we can obtain the weights of fuzzy judgment matrix as equation (4).
4.2. Fuzzy-TOPSIS ranking approach

The Fuzzy-TOPSIS method provides a significant way to deal with un-certain, immeasurable, and incomplete information problem under fuzzy environment. The method based on consists of the following steps:

Step 1. Let $\hat{X}=(x_1, x_2, x_3)$, $\hat{Y}=(y_1, y_2, y_3)$ are the two fuzzy numbers, thus their mathematical relation is as following:

$$\hat{X} + \hat{Y}=(x_1, x_2, x_3) + (y_1, y_2, y_3) = (x_1 + y_1, x_2 + y_2, x_3 + y_3)$$

(5)

$$\hat{X} \times \hat{Y}=(x_1, x_2, x_3) \times (y_1, y_2, y_3) = (x_1y_1, x_2y_2, x_3y_3)$$

(6)

Step 2. Let $\tilde{X}_i=(x_{i1}, x_{i2}, x_{i3})$ be a TFNs for $i \in I$. Subsequently, normalized the fuzzy number of each $x_{ij}$ indicated as:

$$R_{ij} = \left[ \begin{array}{c} \frac{x_{ij}}{x_{ij}^+}, \frac{x_{ij}^-}{x_{ij}^-} \end{array} \right]$$

(7)

For benefit criteria, the normalization processing is shown as below, where * represents the maximum:

$$r_{ij}^* = \frac{x_{ij}^*}{x_{ij}^{*+}}, \frac{x_{ij}^*}{x_{ij}^{*-}}$$

(8)

For cost criteria, the normalization processing is indicated as, where - represents the minimum:

$$r_{ij}^- = \frac{x_{ij}^-}{x_{ij}^{*-}}, \frac{x_{ij}^-}{x_{ij}^{*-}}$$

(9)

Step3. Obtaining the weighted normalized fuzzy decision matrix with regards to each sub-factors: $\tilde{V}=[v_{ij}]_{m \times n}$

(10)

Step 4. Identifying the distance between fuzzy ideal positive solution ($d_i^+$) and fuzzy negative ideal solution ($d_i^-$):

$$d_i^+ = (v_{ij}^+, v_{i2}^+, v_{i3}^+, \ldots, v_{in}^+)$$

$$d_i^- = (v_{ij}^-, v_{i2}^-, v_{i3}^-, \ldots, v_{in}^-)$$

(11)

Here, the distance between two TFNs $\hat{X} = (m_1, m_2, m_3)$, $\hat{Y} = (n_1, n_2, n_3)$ can be as:

$$d(\hat{X}, \hat{Y}) = \sqrt{\frac{1}{3}[(m_1-n_1)^2 + (m_2-n_2)^2 + (m_3-n_3)^2]}$$

(13)

Step 5. Computing the Closeness Coefficient (CCi) for each alternative using the following formula:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}$$

(14)

5. The prioritization of energy strategy path

Based on the combined Fuzzy-Logarithmic and Fuzzy-TOPSIS method proposed above, the prioritization of energy strategy paths are analyzed. The priority of seven aspects mentioned in chapter 3 are confirmed.

5.1. Demanded-oriented reform_1st ranked

China's energy development should transform towards the orientation of seeking efficiency and focus on achieving high-quality. Demand-oriented is the key point, which means to deepen the structural reform of supply side in energy field. Meanwhile, energy industry should pay more attention to the
participation right, so as to fully release the demand-side power to form a situation of supply-demand interaction. Especially, the old way of subsidy-oriented development should be avoid, which has brought about new potential excess capacity.

5.2. Mitigating the contradictions of institutional mechanisms_2nd ranked
It is one of the top priority in current energy strategy to solve the deep contradictions in institutional mechanisms. On one hand, from the perspective of traditional energy development and the discussion throughout the industry, the fundamental way out is to better exploit government macro-control and the decisive role of the market in resource allocation. On the other hand, how to cultivate new energy formats in the new era is particularly noteworthy. For example, in the field of building energy conservation, a series of cross-border integration of management, standards and technology are required.

5.3. Energy technology breakthrough_3rd ranked
Energy security is highly focused by firmly promoting research and innovation of energy disruptive technologies. Firstly, strive to promote subversive energy technologies represented by nuclear fusion, natural gas hydrates and hydrogen energy. Secondly, the key national energy laboratories should be laid out in advance, in order to integrate industry, research and government resources. Thirdly, the connection of basic research and industrialization is to be emphasized, for deeply integrating industry, University and research in energy field.

5.4. Global energy governance_4th ranked
Implementing the Belt and Road Initiative is of great importance by building a community of energy destiny. China should actively participate in global energy governance abroad, providing public goods such as the international system. Meanwhile, participating into IEA and other international organizations, taking part in the formulation of the Energy Charter Treaty rules, as well as taking the B&R Initiative International Cooperation Summit Forum as an opportunity to form and mature China-oriented regional multilateral coordinating organizations.

5.5. Energy enterprise synthesis strength improvement_5th ranked
The risks such as laws and regulations, business rules, political changes, exchange rate fluctuations, environmental protection constraints, contract signing and public relations should be highly considered. China's energy enterprises concentrate consciously more on the promotion of soft power. Especially considering the insufficient global market demand, it is imperative to grab the development demands of target countries and form a community of interests for regional development in terms of business philosophy and general rules of the international market.

5.6. Energy finance system Construction_6th ranked
The construction of energy finance system needs to be accelerated. Giving that the broad demand advantage of China's energy market, it is a good opportunity to join the energy importing countries such as Japan and South Korea in order to continuously expand the scale of market transactions, stimulate market vitality, and gradually build an oil and gas trading center in the Asia-Pacific region. Especially, the issue of oil and gas resources premium should be solved ASAP. The Energy-RMB trading mechanism is important to both energy and financial system.

5.7. Integrated energy system construction_7th ranked
The construction of comprehensive energy system is important. In view of the characteristics of the blurring of energy varieties and the complexity of coupling, the inter-departmental and inter-professional management functions in the energy field are opened up, and the data information of the large energy system needs to change from industry-moat to industry-catalyst.
6. Conclusion
Based on the combined Fuzzy-Logarithmic and Fuzzy-Topsis method proposed, a clear ranking for energy strategy priority is analyzed. Demanded-oriented reform, mitigating institutional mechanisms contradictions, energy technology breakthrough, global energy governance, energy enterprise synthesis strength improvement, energy finance system construction and integrated energy system construction are proposed by priority ranking for energy strategy paths in China. It is expected to be beneficial for the medium and long-term energy planning and policy drafting.

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