Energy 64 (2014) 541–550

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Multi-perspective analysis of China's energy supply security

Jiang-Bo Geng [a,b], Qiang Ji [b,*]

[a] School of Management, University of Science and Technology of China, Hefei 230026, China
[b] Center for Energy and Environmental Policy research, Institute of Policy and Management, Chinese Academy of Sciences, Beijing 100190, China

ARTICLE INFO

Article history:
Received 9 May 2013
Received in revised form
8 October 2013
Accepted 12 November 2013
Available online 9 December 2013

Keywords:
Energy supply security
Multi-dimensional indicator system
Evolution characteristics

ABSTRACT

China's energy supply security has faced many challenges such as the drastic change of the international energy environment and the domestic energy situation and so on. This paper constructs a multi-dimensional indicator system for the main risks deriving from four aspects to evaluate the situation of China's energy supply security and analyze its evolution characteristics from 1994 to 2011. The results indicate that the situation of China's energy supply security generally presented a downtrend during 1994–2008, as a result of increasing international energy market monopoly and high volatility of international crude oil prices. After 2008, the overall level of China's energy supply security has improved to the level of 2003, which is attributed to the relatively stable international energy environment as well as the effective implementation of energy policies.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

In recent years, the situation of China's energy supply security has been worsening, facing a lot of challenges: (1) the balance between energy supply and demand in China has been broken, and this gap has been enlarged. The average annual growth rate of China's energy production was 5.97%, while that of energy consumption was 6.32% during 1994–2011 [1]. (2) Although China's energy self-sufficiency rate remains at a high level (exceeding 90%), the energy self-sufficiency rate of different sub-varieties differs greatly. In 2011, China's dependence on foreign oil and natural gas reached 56.5% and 21.56%, respectively [2], and went on to maintain a sustainable growth trend. According to BP's forecast, China's dependence on foreign oil and natural gas will reach 80% and 42% by 2030, respectively [3]. (3) The volatility of international crude oil prices has a great impact on China's economy. It has increased the production costs of the energy industries and imported inflationary pressures in China. (4) China is facing grim situation in addressing climate change with hard tasks [4]. China is right in the rapid process of industrialization and urbanization. Therefore, high demand for energy in China has increased carbon dioxide emissions constantly. In 2011, carbon dioxide emissions from fuel combustion in China have reached 8979.14 million tons which has become the largest emitter of greenhouse gases in the world [2]. These factors indicate that the security of energy supply in China has been facing pressures and challenges from all aspects. Under this situation, the evolution characteristics of China's energy supply security have been changing over time which should be further analyzed by modelling a dynamic analytical framework based on a multi-dimensional indicator system. By this way, a quantitative evaluation and implications towards making effective energy policies and protecting the security of China's energy supply can be identified and explored.

The definition of energy security has been changed at different stages of economic development. Sovacool et al. [5] provided a synthesized, workable framework for analyzing national energy security policies and performance by drawing from research interviews, survey results, a focused workshop, and an extensive literature review. At present, the more comprehensive and authoritative definition of energy security is given by IEA [6]: Energy security, broadly defined, means adequate, affordable and reliable supplies of energy. According to China's current energy supply situation and energy characteristics, the definition of China's energy supply security in this paper is that the risk of energy supply should be reduced and reliable and adequate energy supply should be ensured within a reasonable price range.

Previous researches on China's energy supply security had focused on the different types of energy sources. Nolan [7] analyzed that Shenhua Group's coal liquefaction technology had potentially strategic significance for China's energy supply security. Zhao et al. [8] argued the coal chemical industry should be oriented to the development of high efficiency, safety, cleanliness, and optimum utilization in China. Zhang et al. [9] built a two-phase DEA-like model to evaluate China's oil import security from a perspective of supply chain process. Downs [10] analyzed the issue of energy

* Corresponding author. Tel.: +86 10 62542627.
E-mail address: jqwxnjq@163.com (Q. Ji).

0360-5442/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.energy.2013.11.036

supply security in China and explained how to deal with the high dependence on foreign oil resources. Zhang [11] considered the strategic importance of the Strait of Malacca to China and pointed out that China had taken great efforts at both the demand and supply sides to cope with the perceived "Malacca dilemma" and enhance its energy security. Leung [12] argued that the transport industry would require the most energy demand in the future and its average energy efficiency need to be improved. Cao and Bluth [13] analyzed the key features of China's energy policy which were related to energy supply security. Bambawale and Sovacool [14] analyzed China's energy security situation from seven aspects using the questionnaires, and the results showed that fossil energy supply security was the most important aspect and environmental factors such as soil erosion, air pollution, and water pollution were the second most important aspects. Jiang et al. [15] suggested China should adopt low-carbon economy, develop new energy, establish related laws, management institutions and mechanisms and enhance the public awareness of energy saving. Zhang [16] argued that both China and the Western countries need to de-politicize China's global quest for energy security.

However, energy supply security has been considered as a complex issue threatened by multi-dimensional risks and obstacles, including domestic resources restriction, energy technological obstacles and international dependence risks and economic threats. Therefore, any single and partial analysis on one aspect can hardly reflect the integrated situation of energy supply security. In order to make a comprehensive analysis of China's energy supply security, multiple aspects should be taken into account. Based on this consideration, a multi-dimensional indicator system of China's energy supply security is constructed including domestic and external risks from four dimensions which provide a new perspective for energy supply security evaluation. By this way, the evolution characteristics of China's energy supply security can be identified and corresponding policy implications can be proposed aiming at the main risks.

The rest of the paper is organized as follows: Section 2 gives the analytical framework of energy supply security evaluation. Empirical results analysis and discussion are presented in Section 3. Finally, some conclusions and policy recommendation are drawn in Section 4.

2. Analytical framework of energy supply security evaluation

2.1. Multi-dimensional indicator system

According to the situation of China's energy supply and demand, and considering the multiple risks that China's energy security has faced, seven composite evaluation indexes are constructed from four risk dimensions: the risk of energy external availability, the affordability of energy import, the development of energy technologies and energy efficiency, and energy resource reserves as shown in Table 1. The multi-perspective analysis of China's energy supply security and its evolution characteristics would help make better policy decisions and also provide a feasible way to track how policy decisions raise China's energy supply security.

2.1.1. The risk indicators of energy external availability

The energy importing from other countries is obtained through trade. On the one hand, the risk of availability of imported energy is influenced by the degree of monopoly in the international energy market. On the other hand, the complexity and high risk of the sources of energy imports has brought uncertainties to the imported energy. This paper constructs the energy export monopoly risk index and the diversification index of energy imports to evaluate the risk of energy external availability.

Table 1
Index system of China's energy supply security.

Evaluation dimension	Evaluation index	Symbol
Energy external availability	Energy export monopoly risk index	X_1
	Diversification index of energy import	X_2
The affordability of energy import	Economic vulnerability index	X_3
	Crude oil price volatility risk index	X_4
Energy technologies and energy efficiency	Clean energy generation ratio	X_5
	Energy efficiency	X_6
Energy resource reserves	Reserve-to-consumption ratio	X_7

2.1.1.1. Energy export monopoly risk index. To analyze the availability risk of China's imported energy associated with the degree of monopoly in the international energy market, this paper refers to Lefevre [17] and constructs the index of energy export monopoly risk ($EMCRI_{export}$). The index is constructed as follows:

$$\begin{aligned} EMCRI_{export} &= \sum_f \left[EMC_{export-f} \cdot E_{import-f}/E_f \right] \\ &= EMCRI_{export-oil} + EMCRI_{export-gas} \\ &\quad + EMCRI_{export-coal} \end{aligned} \tag{1}$$

Where $EMCRI_{export}$ represents the energy export monopoly risk index. The fact that the value of $EMCRI_{export}$ is higher indicates that the risk that energy importing countries obtain energy from the international energy market is greater. $EMCRI_{export\text{-}oil}$, $EMCRI_{export\text{-}gas}$, and $EMCRI_{export\text{-}coal}$ represent the indexes of China's crude oil, natural gas and coal export monopoly risk respectively. $EMC_{export\text{-}f}$ represents the export concentration index for fuel f, $E_{import\text{-}f}$ indicates the amount of energy import for fuel f, and E_f indicates energy consumption for fuel f in China. Equation (1) reflects the degree of the dependence on the energy export market for energy importing countries.

EMC (energy market concentration) uses the HHI (Herfindahl–Hirschman Index) as the measurement. OPEC is considered as a whole because the countries in the OPEC organization coordinate with each other for policies on crude oil output [18]. The index of energy export market concentration (EMC_{export}) is constructed as follows:

$$EMC_{export} = \sum_{i=1}^{n} S_{if}^2 \times 10000 \tag{2}$$

Where S_{if} is the percentage share of each supplier i in the international market for fuel f. EMC_{export} indicates the concentration index of the export market and reflects the monopoly degree of the energy export market. Its value ranges from 0 to 1. A higher EMC_{export} value implies high insecurity.

2.1.1.2. Diversification index of energy import. Diversification in energy import can reduce the risk of supply disruption. For energy importing countries, when the diversification degree of energy import is higher, the risk of energy import is lower. Herfindahl–Hirschman index (HHI) is an indicator of the amount of competition which is widely applied in evaluation models to measure diversification [19]. This paper also uses the format of HHI to measure the diversity of energy supplies by summing the squared shares of all foreign suppliers in the total import volume of China. When some supplier constitutes a larger share of China's energy import volumes, it may bring more potential risk for China's energy imports. Therefore, the index constructed can better reflect the situations of

Download English Version:

https://daneshyari.com/en/article/8078768

Download Persian Version:

https://daneshyari.com/article/8078768

Daneshyari.com