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Energy security in China: A quantitative analysis and policy implications

Lixia Yao [a,b], Youngho Chang [c,*]

[a] S. Rajaratnam School of International Studies, Nanyang Technological University, Singapore 637332, Singapore
[b] Energy Studies Institute, National University of Singapore, 119620, Singapore
[c] Division of Economics, School of Humanities and Social Sciences, Nanyang Technological University, HSS-04-65, 14 Nanyang Drive, Singapore 637332, Singapore

HIGHLIGHTS

- This study establishes a comprehensive and quantifiable energy security concept.
- China's energy security situation appears not to improve over its reform period.
- Domestic policies and reforms attributed to the energy security in China.
- Policy implications of what China implemented and needs to implement are drawn.

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ABSTRACT

This study aims to examine how China's energy security has changed over 30 years of reform and the opening period. It constructs a 4-As quantitative evaluation framework—the availability of energy resources, the applicability of technology, the acceptability by society, and the affordability of energy resources. The quantitative results show that China's energy security was at its best during the sixth FYP period (1981–1985), but then deteriorated until it hit higher levels between 1995 and 2005. However, it was still lower than the level reached during the sixth FYP period. During the eleventh FYP period (2006–2010), the energy security situation deteriorated again. Differences in policy priority over the study period appear to affect the country's energy security status. This study suggests that China needs to develop renewable energy resources on a large scale and pay more attention to emissions control to reverse the downward trend in energy security.

1. Introduction

There have been extensive studies that evaluate and measure a country's energy security. Indicators constructed to measure energy security have focused on the conventional concepts of energy security, such as an adequate energy supply at reasonable prices, and thus measured energy security only from one or two aspects that are incomprehensive. Simple indicators have been used to measure a particular aspect of energy security, such as energy intensity or energy price volatility. Like the simple indicators, aggregated energy security indicators also focus on one aspect of energy security. Energy diversity is the most frequently employed aggregate energy security indicator that measures the sources of energy supply. These indicators can accurately measure a particular aspect of energy security. However, just as the conventional concepts of energy security do not offer a comprehensive view, the indicators and conventional measurements are not able to fully measure a country's overall energy security situation. In addition, existing energy security evaluation and measurement tends to have double counting and end up with an excessively complicated framework.

This study aims to define energy security in a comprehensive manner and construct a quantitative framework on the basis of the energy security concept, which incorporates as many dimensions as possible but reduces the complications to comprehensively reflect an energy security situation. Using the framework and indicators, this study evaluates China's energy security status and examines China's energy security trends by analyzing key energy policies implemented in China and their effects on China's energy security situation. The study starts with the economic reform and opening up period of the Deng Xiaoping Administration in 1980 and ends with the Hu Jintao Administration in 2010. The study

* Corresponding author. Tel.: +65 6513 8107; fax: +65 6795 5797.
E-mail address: isyhchang@ntu.edu.sg (Y. Chang).

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period is split into six five-year periods, which coincide with the periods of Five-Year Plans for National Economic and Social Development (FYP) in China, with the ending year of each FYP as the representative year for analysis. The six periods to be discussed are the sixth (1981–1985), seventh (1986–1990), eighth (1991–1995), ninth (1996–2000), tenth (2001–2005), and eleventh (2006–2010) FYP.

This study presents both quantitatively and qualitatively how the energy security status in China has changed in terms of the four dimensions: the availability of energy resources (AV), the applicability of technology (AP), the acceptability by society (AC), and the affordability of energy resources (AF). To quantitatively measure the energy security situation, ordinal values are converted from the raw data of twenty indicators under the 4-As for the end year of the seven periods under investigation, namely 1980, 1985, 1990, 1995, 2000, 2005, and 2010, with 1980 used as the benchmark. The data are then plotted into seven rhombuses (one for each period) to illustrate the extent of energy security; a rhombus with a larger area means a higher level of energy security. Along with the 4-As framework, this study uses an imbalance index to examine the balance of the development of the four dimensions of energy security in China. The framework and the imbalance index together give a comprehensive picture of energy security in China. These methods are easy to use, clear to interpret, and flexible to expand. Thus, they are not only useful for the quantitative evaluation of China′s energy security situation, but could be applied to the analysis of energy security in other countries.

The quantitative results show that China′s energy security has not improved over 30 years of economic reform. China′s energy security was at its best during the sixth FYP period (1981–1985) and then deteriorated until 1995. During the ninth and tenth FYP periods (1995–2000 and 2001–2005, respectively) the situation improved, but was not commensurate to the level of the sixth FYP period. The eleventh FYP period (2005–2010) also witnessed a worsening energy security situation.

This study is structured as follows. Section 2 presents a review of the existing concept of energy security and establishes the comprehensive energy security concept utilized in this study. This section also gives the rationale for the formation of the concept and the incorporation of the four ‘A’ dimensions. Using the four dimensions, Section 3 constructs a 4-As framework and incorporates twenty indicators in total, with five under each dimension, to analyze the energy security status in China. This section also gives the rationale for the selection of the five indicators under each dimension. This framework, together with the simple but straightforward indicators, provides a good foundation for the further analysis in Section 4, which focuses on data. This section codes the raw data into ordinal and comparable values, scores the performance of energy security status over thirty years of analysis, and examines policy evolution. On the basis of the results presented in Section 4, Section 5 draws policy implications for energy security in China. Section 6 concludes the paper and suggests future research.

2. Concepts and framework of energy security

The concept of energy security has many facets. Various studies have attempted to define energy security with different components, but the most frequently cited definition is a reliable and adequate supply of energy at reasonable prices (Yergin, 1988; Bielecki, 2002; Clingendael International Energy Programme, 2004; International Energy Agency (IEA), 2007; Chang and Lee, 2008; Lin, 2009). These three components of energy security cover the two main dimensions of the concept: economics and technology. As environmental protection has been increasingly drawing public attention, a new dimension – the environment – has been added to the energy security concept (International Energy Agency (IEA), 2007; CNA Military Advisory Board, 2007; von Hippel et al., 2009). Many international organizations incorporate an environmental aspect when defining energy security (Asia Pacific Energy Research Centre (APERC), 2007; European Commission, 2000; United Nations Development Programme (UNDP), 2004). In addition, other factors have been identified as new challenges that should be incorporated as dimensions in the concept of energy security, such as human security, international relations and foreign policy, and so on (Alhajji, 2007; Nautilus Institute for Security and Sustainable Development, 1998; Vivoda, 2010; von Hippel et al., 2009).

These facets show that energy security is an issue so complex that a holistic approach is needed to “capture the complexity of the concept” (Sovacool and Mukherjee, 2011). A few attempts at ‘holistic notions’ have been put forward. For example, an early framework suggested by Chang and Yong (2007) incorporates the availability of resources (AV), the applicability of technology (AP), and the acceptability by society (AC) to analyze the perspectives of major oil firms including their perceptions of energy developments and projections of energy potentials. Chester (2008) uses a four-dimensional grid of availability, adequacy of capacity, affordability, and sustainability to examine Australia′s existing and proposed policies that drive the country′s energy security in terms of the four dimensions. Kruyt et al. (2009) classify energy security dimensions by the availability, accessibility, affordability, and acceptability of energy and use them to analyze the energy security of Western Europe over the next few decades. von Hippel et al. (2009) establish a framework of six dimensions to identify the relative benefits and costs of future energy paths driven by energy policies.

The above concepts of energy security and the frameworks to evaluate the level of energy security show that the notion of energy security has become multi-dimensional. The path towards multi-dimensionality, to some extent, exhibits the historical evolution of the concept. First, all of the definitions, broad or narrow and with whatever dimensions incorporated into the concept, emphasize the economic aspect of energy security: the supply of energy to a nation must be ‘adequate’ and ‘reliable’ and energy prices must be ‘reasonable’ or ‘affordable’ to the population. To interpret this alternatively, a country must hedge against the risk of inaccessibility to energy resources or fluctuation of energy prices. This is the emergence of the first dimension – the economic dimension – of energy security. Later on, rapid economic development and high energy consumption require the efficient use of energy. The demand for more energy resources and energy efficiency improvements requires technological innovation. Accordingly, the second dimension – the technological dimension – of energy security has been incorporated in the concept. Harnessing and utilizing energy has created a major source of environmental pollution, and environmental deterioration is a threat to ecosystems and human health. Therefore, environmental protection is taken into account by including the third dimension – the environmental dimension – in the concept of energy security. It must be noted that these ‘dimensions’ are only implicitly expressed in the broad and narrow definitions. The notion of ‘dimension’ (or ‘aspect’ or ‘theme’) has only been recently introduced in the interpretation of the concept of energy security.[1]

Along with social development and changes in domestic and international conditions, more dimensions are included in the concept of energy security such as social factors, international relations, human security, energy policy and regulations, and so on. Continually adding dimensions to the concept makes energy security just “like a Rorschach inkblot test” where “you can see whatever you

[1] See Asia Pacific Energy Research Centre (APERC) (2007), Chang and Yong (2007), Chester (2010, 2008), Sovacool and Brown (2010), Sovacool and Mukherjee (2011), Sovacool et al. (2011), Vivoda (2010), von Hippel et al. (2009).