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Residential natural gas price affordability analysis—A case study of Beijing

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ABSTRACT

In recent years, the demand for natural gas has shown strong growth in China. However, the relative lack of domestic natural gas resources and dependence on gas imports have resulted in rising natural gas prices. In order to ensure market order, the natural gas pricing mechanism must be closely linked to customer affordability. The objective of this paper is to analyse natural gas prices' economic and psychological affordability for Beijing's residents by the income-expenditure elasticity model and the equivalent heating value method, and further to evaluate the comprehensive affordability of the natural gas price by the small-taking and interval-number methods. Finally, it provides some suggestions for the formulation of Beijing's residential natural gas prices.

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1. Introduction

Natural gas and renewable energy have been considered the key elements of a transition to cleaner and more secure energy in the future. In China, more and more industries are paying attention to

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the use of natural gas and renewable energy, especially in the electricity sectors. There are many complementarities in the natural gas and renewable energy in the aspects of economy, technology, environment, which are not only from their similarities, such as the benefit to energy saving and environmental protection compared to coal and oil, but also from their differences, such as energy efficiency, people's acceptability and so on [1].

Energy resources are short, and ways of conducting energy management and rational use of renewable energy have become focuses for the Chinese government. Residents of the country also take a supportive attitude towards the development of clean energy because of its positive impact on the environment [2]. Residential natural gas price reform is considered a very important aspect of China's energy price reforms, and has been a matter of widespread concern in the community. Residential natural gas price affordability has always been the primary consideration of natural gas pricing reform for the Chinese government, and it is also focused by the public in the natural gas price hearing. The natural gas tariffs are controlled by the National Development and Reform Commission (NDRC). The ex-factory price of the domestic natural gas is formulated according to the principle of "cost-plus" pricing, while the prices of imported pipeline natural gas and LNG are executed in accordance with the FOB prices of the contract, which leads to different natural gas sources taking different prices. This non-market pricing mechanism to adjust prices according to changes in cost not only leads to variation in the different items of imported and domestic gas prices, but also severely depresses the value of precious domestic natural gas resources. It is difficult for energy prices to correctly guide rational consumption of natural gas, so studying residential natural gas price affordability plays a guiding role in the formulation of policies which are of benefit for the national economy's development and socially sustainable development.

At present, both qualitative analysis and quantitative analysis is being undertaken in the study of energy price affordability. The methods of literature study, questionnaire and mathematical statistics are generally used in the analysis of price affordability. Jelena and Nevenka [3] analysed Slovenian residential willingness to pay for green electricity based on a linear regression model, and concluded that age, household income, education level and environmental awareness are the main factors. Andre et al. [4] took Sweden as the research subject to analyse consumer willingness to pay electricity bills in a study undertaken by mail questionnaire, and the results show that willingness rose with the use of green electricity. Nikolaos et al. [5] studied residential renewable energy price affordability and influencing factors in Crete based on the double-bounded dichotomous choice model, and concluded that each household is willing to pay an average of 16.33 euros for renewable energy for each quarter in the form of an additional tariff. And residents with a high income or strong environmental awareness are willing to pay more than others. Ryan [6] divided the respondents into two types—collective and voluntary payments—and used a dichotomous choice-contingent valuation survey to explore willingness to pay for renewable energy, concluding that collective payment has higher WTP than voluntary payment in the United States' standard renewable energy policies. Jihyo et al. [7] also used the contingent valuation method to analyse residential willingness to pay for renewable energy in South Korea, and found the average household was willing to pay an additional sum of US\$1.35 per month. Zhang et al. [8] studied urban residential willingness to pay for green electricity in Jiangsu Province based on contingent valuation method; the average WTP per month ranged from 7.91 yuan/month to 10.30 yuan/month; Yuan et al. [9] used the regression model to analyse residential willingness to pay the different tariffs based on a questionnaire collected in four cities in China, concluding that public's environmental awareness should be raised during the implementation of

the different tariff and the additional price that the public will be accept might be slightly lower than 0.05 yuan/kWh. Mou [10] and Yin et al. [11] analysed the natural gas price affordability of various types of consumers based on the equivalent heating value method, finding that there were some differences in affordability for various types of consumers. In addition, some scholars have explored the price affordability of some resources. Taking Chongqing as an example, Wang et al. [12] analysed residential affordability of water price based on the multi-sector discrete choice method, and suggested that if government wants to propose raising the water price, subsidies should be provided for economically disadvantaged families.

In summary, the theoretical research on the natural gas price affordability in Beijing are less at present. This paper divides residential natural gas price affordability into two parts, including residential economic affordability and psychological affordability. Through the income-expenditure elasticity model and the equivalent heating value method, used to analyse residential natural gas economic affordability and psychological affordability respectively, this paper takes Beijing as an empirical study and comprehensively analyses residential natural gas price affordability, further providing some suggestions for the formulation of Beijing's residential natural gas price.

2. Influencing factors of residential natural gas price affordability

Residential natural gas price affordability reflects not only the relative relationship between per capita disposable income and natural gas expenses, but also the ability to accept and afford certain increases in the natural gas price. Residential natural gas price affordability is mainly divided into economic affordability and psychological affordability, which are influenced by per capita disposable income, the price of alternative energy and residential environmental awareness.

2.1. Per capita disposable income

For residents, the higher their disposable income, the higher the natural gas price they are able to withstand. From experience of the world's natural gas market development, when per capita disposable income reaches US\$ 1000, residential natural gas consumption will grow rapidly. With economic and social development, per capita disposable income increases gradually, with which residents' natural gas price affordability will also improve significantly.

2.2. The price of alternative energy

Alternative energy to natural gas has two meanings in this paper: the first is other types of energy, including coal, refined oil, liquefied petroleum gas (LPG), electricity and new energy. The higher the prices of these alternative energy sources, the higher the users' willingness to pay for natural gas prices. The other refers to natural gas in surrounding or adjacent areas; the price of alternative energy is made up of the natural gas price in surrounding or adjacent areas and pipeline transmission cost.

Taking China's urban residents as an example, in the first meaning, the household fuels currently used are coal, liquefied petroleum gas, pipeline gas, electricity, etc. If the natural gas price is higher than the lowest price of other isocaloric energy sources, the residential psychological affordability of natural gas prices will be relatively weaker. In addition, new energies such as wind and solar energy have a substitution effect for natural gas due to their energy-saving features. The National Grid Corporation in China launched a free grid connection for new distributed energy to

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