Energy 157 (2018) 162–172

Contents lists available at ScienceDirect

Energy

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

# Evaluation of increasing block pricing for households' natural gas: A case study of Beijing, China

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ARTICLE INFO

*Article history:*
Received 8 December 2017
Accepted 23 May 2018
Available online 24 May 2018

*Keywords:*
IBP policy
EIR-ELES model
Price elasticity
Price affordability
Residential natural gas

ABSTRACT

In order to promote reasonable resource utilization and improve social equity, all cities with gas supply in China has implemented increasing block pricing (IBP) policy for residential natural gas from Jan. 2016. This paper examines the IBP structure of residential natural gas from the perspective of demand analysis. Based on Expenditure-Income Ratio (EIR) method and Extended Linear Expenditure System (ELES), a new EIR-ELES model is proposed to estimate natural gas price affordability of different kinds of residential users by considering the effect of electricity substitute on household natural gas consumption. Taking Beijing as an example, an empirical research is carried out in this paper. The results show that average price elasticity of residential natural gas demand is −0.4621 in 2016, inelastic; residential natural gas average price affordability is between 4.17 and 7.48 CNY/m3 in 2016, which is much higher than the prices in three blocks, but basic volume of demand for residential users with different income levels are much lower than the volume in the first block. Based on these results, future directions and actions for the design and improvement of residential natural gas IBP system are suggested.



## 1. Introduction

China's energy consumption is highly dependent on coal in a long time. In recent years, driven by environment problems and emission reduction, Chinese government has been working to increase the share of natural gas in the energy mix [1]. Like renewable energy, natural gas is also regarded as a kind of clean energy. Renewable energy, no doubt, is the main substitute for oil and coal over long term in China. However, in the short and medium term, natural gas will play a critical role in the sustainable development of China's economy and environment [2]. The average annual growth rate of natural gas consumption was as high as 14.2% between 2000 and 2016 in China [3]. The share of gas in China's primary energy consumption structure in 2016 was approximately 6.2%, while that in 2000 was only 2.2%. Since 2007, China has become a net gas importer, and its dependence on foreign natural gas has steadily increased; in 2016, the amount of imported natural gas in China reached 72.3billion cubic meters, and its degree of foreign dependence was 34.2% [3].

Fig. 1 shows China's natural gas consumption structure: the residential sector in China is the second largest sector of gas consumption, following the industrial sector. In fact, amount of gas consumption in residential sector is only lower than that of manufacturing sector in the industrial sector. In 2015, natural gas consumption in industrial sector was 123.4 billion cubic meters, among which 71.9 billion cubic meters is consumed by manufacturing sector. While residential gas consumption was 36.0 billion m3, accounting for 18.6% of the total natural gas consumption, which was much smaller than the share of manufacturing industry in total natural gas consumption (i.e., 37.2%). However, residential natural gas consumption grew faster than that in manufacturing sector and industrial sector as well. The average annual growth rate of residential natural gas consumption reached 17.5% between 2000 and 2015 in China, while that in manufacturing sector and industrial sector were only 12.8% and 12.9% respectively [4,5]. Existing literature shows that the rapid constructions of natural gas transportation pipeline, the increasing income of households, along with the lower price of residential natural gas in China are the three primary driving forces of the fast increase of residential gas consumption [6–8].

Though government tries to increase the percentage of natural gas in primary energy, the fast growth of demand may cause “gas shortage”. What's more, as a scarce resource, the luxury consumption of natural gas is a kind of waste. In addition, residential

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https://doi.org/10.1016/j.energy.2018.05.150
0360-5442/

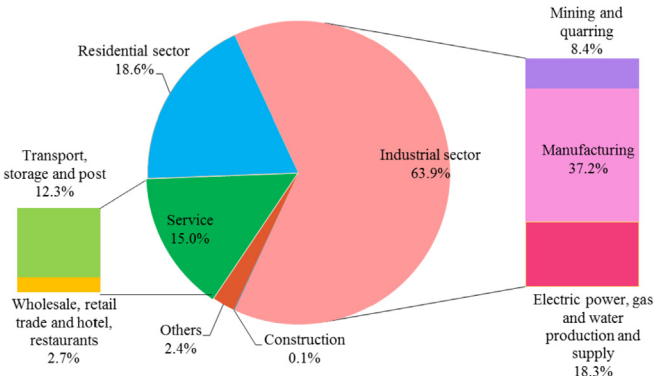


**Fig. 1.** China's natural gas consumption structure in 2015.
**Data source:** National Bureau of Statistics.

gas price was much lower than that of industrial and commercial consumers, which caused non-target cross-subsidies and the inequity among different sectors [9–11]. Therefore, in Mar. 2014, the National Development and Reform Commission (NDRC) issued an increasing block pricing (IBP) policy in natural gas consumption for residential consumers in China. The goals of IBP policy mainly include rational consumption and gas saving, reducing cross-subsidization while guaranteeing neutral income and the basic amount of demand of households, then to realize justice and equity. The three blocks IBP policy was designed according to the following principles: the volume of gas consumption in the first block is determined by covering about 80% households, so as to ensure households' basic living requirements; that of the second block covers about 95% households, which reflects the reasonable gas demand for improving the life quality of residents; and the volume in the third block is the part beyond the second block. The price in the first block is determined according to the principle of basic compensation for the cost of gas supply, and it is relatively stable in a certain period; the price in the second block is formulated based on the principle of reasonable compensation costs and obtaining reasonable profit, and the price level is about 1.2 times of that in the first block; and the price in the third block is laid down in accordance with the principle of fully reflecting the scarcity of natural gas resource and curbing excessive consumption, and the price level is about 1.5 times of that in the first block. Under the IBP policy, the average gas price will rise, which can reasonably compensate the cost of gas supply, reduce the cross-subsidization from industrial and commercial users to residential users, and guide the users to save gas; at the same time, households who consume more gas will bear a higher gas price, while users who consume less gas will have a lower gas price, so as to achieve income redistribution and embody fair burden. Currently, most cities have proposed their own IBP policies under the guidance issued by the NDRC, and implemented the new policy from Jan. 2016. The IBP policies of some cities in China are shown in Table 1. Under IBP system, household gas prices would be set into three tiers based on the volumes of gas use. In other words, households will pay a low price for an initial consumption in the first block, and a higher price as their gas consumption exceeds that block [12,13].

Whether the IBP policy could achieve above objectives depends on the structure design of the IBP system, i.e., the determination of two kinds of parameters: breakpoints of consumption between blocks and marginal prices of blocks, which requires a demand analysis of residential natural gas, mainly involving the estimation of price affordability, price elasticity of demand and so on. As a matter of fact, gas price policies with three blocks have been proposed under the guidance of NDRC across regions in China. Reviewing these policies, it can be find that those breakpoints among IBP policies of regions are very close, and the prices in the second and the third block are respectively 1.2 times and 1.5 times the price in the first block (See Table 1), which overlooks the demand characteristics of different regions. The paper, based on customer demand analysis, aims to explore the problems and disadvantages of the structure design of existing IBP policy and offer some references to improve IBP policies for residential gas consumption. Taking Beijing as an example, an empirical case study about the demand analysis for household natural gas is conducted. Moreover, considering the impact of household income on consumption behavior, residential users in Beijing city are divided into five categories. Firstly, according to time series data from Beijing Statistical Yearbook between 1986 and 2017, the price elasticity of natural gas demand and the basic amount of demand of households with different income levels are estimated by Extended Linear Expenditure System (ELES); Secondly, a new composite model (IER-ELES) is established based on Income-Expenditure Ratio (IER) model and ELES, and this new model is used to evaluate natural gas

**Table 1**
IBP policies for household natural gas in China's major cities.

| Cities | Flat price (CNY/m3) | Implementation date | IBP policies | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Natural gas quantity (m3) | | | Price (CNY/m3) | | |
| | | | Block 1 | Block 2 | Block 3 | Block 1 | Block 2 | Block 3 |
| Beijing | 2.28 | 2016.01 | ≤350 | 350–500 | >500 | 2.28 | 2.5 | 3.9 |
| Shanghai | 2.5 | 2014.09 | ≤310 | 310–520 | >520 | 3 | 3.3 | 4.2 |
| Tianjin | 2.4 | 2015.11 | ≤300 | 301–600 | >600 | 2.4 | 2.88 | 3.6 |
| Guangzhou | 3.45 | 2016.01 | ≤320 | 320–400 | >400 | 3.45 | 4.14 | 5.18 |
| Nanjing | 2.2 | 2016.01 | ≤300 | 300–600 | >600 | 2.5 | 3 | 3.5 |
| Wuhan | 2.53 | 2016.01 | ≤360 | 360–600 | >600 | 2.53 | 2.78 | 3.54 |
| Changsha | 2.45 | 2014.12 | ≤360 | 360–600 | >600 | 2.45 | 2.94 | 3.68 |
| Xi'an | 1.98 | 2016.01 | ≤480 | 480–660 | >660 | 1.98 | 2.38 | 2.97 |
| Chengdu | 1.89 | 2016.01 | ≤500 | 500–660 | >660 | 1.89 | 2.27 | 2.84 |
| Yinchuan | 1.63 | 2016.01 | ≤336 | 336–480 | >480 | 1.63 | 1.96 | 2.45 |
| Kunming | 3.31 | 2016.01 | ≤360 | 360–540 | >540 | 3.31 | 3.97 | 4.97 |
| Changchun | 2.8 | 2016.01 | ≤300 | 300–400 | >400 | 2.28 | 3.36 | 4.2 |
| Lanzhou | 1.7 | 2015.11 | ≤360 | 360–480 | >480 | 1.7 | 2.04 | 2.55 |
| Nanchang | 3.2 | 2016.01 | ≤420 | 420–660 | >660 | 3.2 | 3.52 | 3.84 |
| Nanning | 3.82 | 2016.01 | ≤360 | 360–600 | >600 | 3.82 | 4.58 | 5.73 |
| Taiyuan | 2.26 | 2016.01 | ≤312 | 312–456 | >456 | 2.26 | 2.71 | 3.39 |
| Guiyang | 3.2 | 2016.01 | ≤480 | 480–660 | >660 | 3.05 | 3.6 | 4.5 |

**Date source:** NDRC and price bureau websites in various cities.