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Electricity tariff reform and rebound effect of residential electricity consumption in China

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ABSTRACT

China has implemented increasing-block power tariffs. It might be a breakthrough in the country's stagnant residential power tariff reform. Improving energy efficiency is the primary method adopted by the Chinese government for energy conservation in residential sector. However, negative effects brought by energy rebound would weaken the real effect of efficiency improvement. Therefore, this paper focuses on the impact of residential electricity tariff adjustment on rebound effect of residential electricity consumption in China. We set up an LA-AIDS Model (linear approximation of the almost ideal demand system model) to estimate the rebound effect of urban residential electricity consumption. The results show that the rebound effect is approximately 165.22%. This figure manifests the existence of 'backfire effect', indicating that efficiency improvement does not have energy-saving effect in practice. After the implementation of increasing-block electricity tariff policy in China, the rebound is reduced to 132.3%. In addition, we also obtain the electricity tariffs at which the rebound effect is less than 1 or even close to zero. In this regard, for Chinese electricity market, electricity tariff reform might be an effective method for mitigating rebound effect.

1. Introduction

According to World Energy Council, "energy conservation" is defined as to take all measures that are technically and economically feasible and environmentally friendly to improve energy efficiency. This definition is based on energy substitution theory, and indicates that energy efficiency improvement is equivalent to energy saving. Within an economy system or a specific sector, energy and capital are inter-substitutive under certain conditions. Capital substitutes energy through capital investment for energy consumption reduction. For example, R&D investment on energy-saving technology would improve energy efficiency of energy services or energy products, and reduce energy consumption. Energy conservation is to be made primarily through the deployment of efficient energy-using technologies [1]. However, it is important to support energy-saving and emission-reduction with proper strategies and policies, rather than simply increase investment on technology progress and research [2]. The existence of energy rebound effect has questioned the energy-saving effect of improving energy efficiency. Energy efficiency improvement cuts down the effective cost of energy, which will increase energy service demand as well as energy consumption. The energy consumption increment offsets the energy-saving effect, and that is the energy rebound [3].

The existence of energy rebound effects is widely accepted in the field of energy economics while the controversy only lies in its source and size [4]. Only when energy rebound effect is less than 100% can energy efficiency improvement have some energy conservation effects. In contrast, if energy rebound effect surpasses 100%, energy consumption would be increased rather than reduced when energy efficiency is improved. This is called "backfire effects" [5]. Sorrell and Dimitropoulos [6] find that energy rebound effect in developing countries or transitional economies are more significant than that in mature economies. According to the existing studies, we find that energy rebound effect in China is generally higher than that of corresponding sectors in developed countries and this result can be seen obviously in the Wang's research [7]. Therefore, it has great academic significance to study how to mitigate energy rebound in China's national economic and social sectors.

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In this paper, we will study the impact of residential tariff on rebound effect of residential electricity use. China is the largest developing country and the government-controlled low residential tariff brings out a lot of drawbacks. One is power shortage which is induced by the continuous loss of power plants when facing increasing power production costs. Also, the inefficient cross-subsidy also brings out the problem of unfairness. Lin et al. [8] found that due to the low residential tariff, the 22% poorest residents only got 10.1% of total power subsidy, while the richest 27% residents shared 45% of power subsidy. Moreover, the contradictions caused by the low residential electricity tariff became even worse. Then, the Chinese government determined to reform the residential power tariff, officially issued the "Draft of implementing the reform of increasing-block residential power tariff" on October 9, 2010, to collect public opinions about the implementation of increasing-block residential power tariff.

In this paper, we calculate the rebound effect of residential electricity consumption before the residential tariff reform, and then carry out policy simulation to study how the implementation of increasing-block electricity tariffs affects the rebound effect. The remainder of the paper is organized as follows. Section 2 describes the current situation of electricity consumption and electricity price in Chinese household sector. Section 3 describes energy rebound effect from theoretical perspectives and provides the literature review. Section 4 conducts empirical analysis, describes the data adopted, specifies the econometric model, and provides the empirical results. Section 5 carries out the policy simulation to reveal the impacts of increasing-block electricity tariffs on rebound effect of residents' electricity consumption. Section 6 gives the main conclusions and policy recommendations.

2. Power consumption and tariff in residential sector

2.1. Residential electricity consumption

China's social total power consumption shows sustained growth correlating to the level economic development, with average annual growth rate of 13% during the last twenty years [9]. Over 1990–2000, power consumption of residential sector experienced a rapid growth, with average annual growth rate of 16.1% [10]. After then, restricted by the remarkable rising of industrial electricity consumption, its growth slowed down, which was approximately 12.9%. But this figure is still slightly higher than that of social total electricity consumption (10.9%). Meanwhile, the proportion of residential electricity consumption in total electricity consumption is around 12%, with a small increase. As shown in Fig. 1, in 2011, residential electricity consumption reached 564.6 thousand million kWh, approximately equal to that of tertiary industry, more than that of primary industry, and far less than that of secondary industry. In addition, per capita electricity consumption in China is much lower, only one fifth of that in United States and one seventh of that in Japan [9].

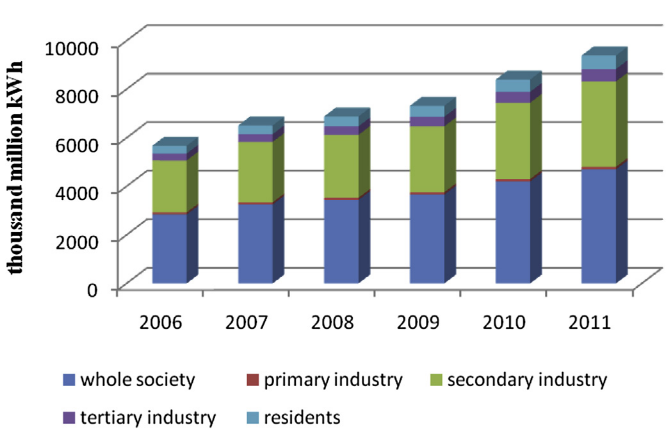

Fig. 1. Power consumption situation in China (thousand million kWh).

In modern society, consumers' lifestyle and expectation of electricity price would determine their power consumption strategy/behaviors. Compared with other countries, the much lower proportion of residential electricity consumption and much less per capita power consumption in China indicates a substantial room for residential power consumption increase. Firstly, the substitution of electricity for other types of energy is an important feature of social modernization. China now is in the transitional stage, the increasing per capita income encourages residents to pay more attention to the comfort and convenience of life, which would raise residential electricity demand. Secondly, with on-going urbanization, rural residents in China will flood into -urban areas. Average power consumption of each urban resident is about 1.4 times than that of a rural resident [11]. This part of "marginal consumers" called by Orasch [12] who are new consumers after raising up the affordable ability, will undoubtedly further increase the electricity consumption of residential sector.

2.2. Residential power tariff

Power tariff in China is determined by the government, and is priced not based on electricity generation costs, but on historical prices and the need for the new charges [13]. Now, we analyze the current situation and features of China's residential tariff by comparing power tariffs of different countries.

Table 1 shows that both residential tariff and industrial tariff in United Kingdom, Germany and Japan are generally higher. It is because the fuels for power plants in these countries mainly depend on imports, and high energy prices in the international market result in their higher generation costs. According to Table 1, power tariff in China has two aspects of features. First, China is the unique country where residential electricity prices are lower than industrial electricity tariffs. Under this pricing scheme, industrial electricity price is above the marginal production cost of electricity but residential tariff is not [8]. The Chinese government implements such an electricity tariff policy aiming to cut down residents' electricity bill and relieve their living burden. In fact, under this pricing mechanism, industrial and commercial sectors bear high electricity prices, whose costs actually subsidize residents' electricity consumption. Second, the residential electricity tariff in China is far less than that of developed countries.

According to Table 2, over 2003–2008, due to rising fuel costs, average annual growth rate of industrial tariffs and residential electricity prices in France were about 9.4% and 9.5%; the

Table 1
Electricity tariff of different countries in 2008(Yuan/kWh).

	Residential tariff	Industrial tariff	Residential/industrial
The United States	0.784796	0.486157	1.61
The United Kingdom	1.604318	1.013985	1.58
Germany	1.826561	0.757016	2.41
Japan	1.430691	0.805632	1.78
Korea	0.618114	0.416706	1.48
Taiwan	0.597279	0.465322	1.28
China	0.52	0.6875	0.76

1. Electricity price data of countries except China are from Ref. [14].
2. Average exchange rate in 2008, $1 = 6.9451 Yuan.
3. Limited by data availability, electricity price of Germany is the 2007 data.
4. Industrial electricity tariff in China is the common industrial electricity price.