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An empirical case study about the reform of tiered pricing for household electricity in China

Chuanwang Sun *

Collaborative Innovation Center for Energy Economics and Energy Policy, China Institute for Studies in Energy Policy, School of Economics, Xiamen University, Xiamen, Fujian 361005, China
Department of Economics, College of Arts & Sciences, Cornell University, Ithaca, NY 14850, USA

HIGHLIGHTS

- We investigated the effect of TPHE on achieving the twin objectives of efficiency and equity.
- The TPHE improved efficiency by promoting household electricity conservation.
- The TPHE realized the targeted-subsidy of residential electricity consumption.
- We explored subsidies reallocation among different income groups under the scheme of TPHE.

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ABSTRACT

The reform of tiered pricing for household electricity (TPHE) in China was implemented nationwide in July 2012. The main purpose of the policy is to promote reasonable resource allocation and utilization. Based on the micro household-level survey data, this paper investigates the effect of the TPHE on achieving the twin objectives of efficiency and equity respectively. Results demonstrate that under the current scheme of the TPHE, the incentives for electricity conservation are effective and the distortion of cross-subsidies in electricity tariffs in China has been reduced. However, price sensitivities of household electricity demand across different income groups are influenced by various factors. Future policy should concentrate on the design and improvement of the TPHE to establish a comprehensive pricing mechanism. Meanwhile, complementary policies should be enacted to support the TPHE, which will be helpful for further improvement of the TPHE and the establishment of other pricing mechanisms of resource-products in the residential sector.

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1. Introduction

The Chinese central government has announced to carry out energy price reform, which aims to establish a rational energy pricing mechanism and resolve issues of resource pricing and efficiency [1]. Energy price reform in China has recently reached a "critical" stage, because the reform object – the residential sector is quite sensitive [2]. In particular, the electricity pricing mechanism, which is closely related with resident life, attracts increasing attention from economist and policy makers. Based on the comprehensive opinion poll and rigorous analysis, the National Development and Reform Commission (NDRC) proposed the tiered pricing for household electricity (TPHE) in China in November 2009. Under this pricing system, household electricity prices will be set in three tiers based on the volume of electricity consumption. Specifically, households who consume more electricity will be forced to internalize the costs of higher electricity consumption, while other households who consume less electricity will be left intact. The implementation of TPHE has two positive effects. First, the integration relation between electricity price and household electricity consumption will promote the efficiency of electricity consumption. Second, the TPHE makes sure that subsidies to electricity consumption would be distributed to the neediest people. In general, the TPHE not only stimulates the potential for residential electricity-saving, but also phases out untargeted energy subsidies that favor the rich rather than the poor. In 2014, the National Energy Bureau issued the energy work guidance, indicating that the reform of electricity sector would be further promoted. Since the attention to the sustainable development and social welfare is continuously growing, the pricing mechanism of electricity, which has to satisfy objects of both efficiency and equity, is on the top of the government's agenda.

* Address: School of Economics, Xiamen University, Xiamen, Fujian 361005, China. Tel.: +86 5922186076; fax: +86 5922186075.
E-mail address: cw_sun@foxmail.com

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Since the concern about the electricity pricing mechanism is continuously growing all over the world, the public investigation and analysis over the scheme, goals and effects of different electricity pricing mechanisms are abundant. Thus, we integrate some typical studies for comparison analysis (see Table 1). We can find that many electricity pricing mechanisms are different, and each mechanism has different electricity tariffs. Filippini [3] analyzed the panel data of 40 cities in Switzerland during 1987–1990 and concluded that "Time-of-Use Electricity Rates" were more efficient than the overall increase in electricity prices. Under same electricity pricing mechanism in Norwegian, Ericson [4] found that higher demand flexibility tended to increase the propensity to select dynamic tariffs, while consumption patterns did not significantly influence tariff choice. Using time series data of Turkey during 1971–2006, Dilaver and Hunt [5] showed that price elasticity of residential electricity demand ranged from −0.10 to 0.57, while the elasticity of residential electricity consumption was between 0.41 and 2.29. Wang and Li [6] reported a survey of 43 Time-of-Use (TOU) pricing programs targeted industrial customers and offered by U.S. utilities, and examined various industrial scenarios to predict electricity cost savings when customers were facing the transition from flat rates to TOU pricing. Erdogdu [7] analyzed the impacts of market reform on electricity prices and cross-subsidies in the electricity sector using panel data of 63 countries during 1982–2009. Results showed that the fixed or consistent electricity market model couldn't be adopted by different countries or regions, and the levels of electricity price and cross-subsidies should be decided by factors such as the national electricity consumption, income levels and regional characteristics. Chattopadhyay and Duflo [8] indicated that the cross-subsidization of electricity price in India was inefficient and unsustainable, and proposed the corresponding reform plan. Upton et al. [9] provided information on electricity consumption change and costs on dairy farms through the simulation of various electricity tariffs, and how these tariffs interacted with changes in farm management. For most countries such as Norwegian, America and Japan, the TPHE (including time-differentiated tariffs and amount-differentiated tariffs) is a widely used mechanism in residential electricity sector.

It is not easy for the government to make a rational decision on residential electricity pricing, especially in China, which is experiencing a vital political and economic transition. A large number of empirical studies on the mechanism for residential electricity in China mainly focus on price sensitivities and subsidies.

Price sensitivities of residential electricity consumption are influenced by many factors, and one of the most important factors is household disposal income. Some macro factors (such as population growth and urbanization rate) and individual preference (such as lifestyle) also effect electricity consumption. Thus, Holtedahl and Joutz [10] discussed the influences of household disposable income, population growth, electricity price, rate of urbanization and temperature on residential electricity demand in Taiwan. Using the logit regression model, Wang et al. [11] analyzed the willingness and behavior of residential energy saving and concluded that the economic benefits, consumption habits, social norms and policies had positive impacts on residential electricity saving in Beijing. The complex price sensitivities of residential electricity consumption required a non-linear pricing mechanism that could distribute electricity to the one who had higher demand, and the utilization efficiency would be improved. Lin and Jiang [12] showed that the single electricity price system couldn't solve the complex social and environmental issues so that China should design the four-ladder increasing block electricity tariffs to promote equity and efficiency. In general, the TPHE provides opportunities for households to choose the energy-efficient lifestyle and thus encourages electricity saving.

A reasonable price mechanism is conducive to improving the effectiveness of subsidies and ensuring the equity of allocation. Under the former subsidy mechanism, most subsidies went to high-income residents [13] and it is urgent to reform the inefficient cross-subsidies [14]. Therefore, it is necessary to discuss the optimal allocation of cross-subsidies among different income groups.

The principal goal of this paper is to evaluate the effectiveness of the TPHE policy. Specifically, there are four distinctive reasons for studying the effect of TPHE reform.

First, the nationwide TPHE reform in China, which is the reform of residential energy pricing for the first time, would have an important impact on the energy consumption behavior of 1.4 billion people. In other words, household energy saving actions would likely be stimulated in this new integrated power tariff system. To our knowledge, the relative research rarely paid attention to the analysis of the reform effect about efficiency and equality. Since the reform features the influence on the behavior of microeconomic entities, we investigate the price sensitivity of different households, and evaluate the reallocation of the residential electricity subsidies. Therefore, studying the energy pricing reform of residential sector offers an opportunity to understand the revealed preference of household decisions about electricity use, and we contrast their choices with the goal of public policy makers.

Second, except for the household income which has been commonly considered in the previous research (e.g., [14]), our study introduces three variables related with the TPHE reform, and examines whether these variables have the significant impact on the energy saving behavior. The first one is the household energy expenditure. To optimize the household utility and minimize energy expenditure, households which have higher electric bills might be more sensitive to the TPHE reform, and would be more likely to take energy saving actions. The second variable is a dummy, which investigates whether households have installed solar water heaters before the reform. If households have already taken energy saving actions such as the installation of solar water heaters, they might be more motivated by the price reform. The third variable is also a dummy, which evaluates whether households understand the TPHE reform. In our study, we first examine the relation between the policy understanding level and the policy effect, and then conduct a further analysis on the investigation of whether the relation varies among different income groups.

Third, in order to evaluate the actual effect of the policy, we use the data after the implementation of TPHE reform. Different from the advanced assessment in previous research of Lin and Jiang [12], we adopt the micro household-level survey data in 2013 and 2014, and quantitatively estimate the redistribution of residential electricity subsidies. The empirical results show that compared to the case before the reform, the TPHE reform not only improves the equality of subsidies allocation among different income groups, but also reduces 6.62% of subsidies to residential electricity consumption.

Fourth, our empirical analysis highlights the positive role of TPHE reform in the improvement of efficiency and equality, and provides answers to the debate about the efficiency of the implementation of the TPHE (e.g., [15,16]). In other words, the TPHE reform makes households more sensitive to energy price change, and provides incentives for households to take energy saving actions. However, the process of energy price reform in China is still slow. We argue that more targeted design of the TPHE should be promoted gradually and progressively to achieve the maximized efficiency and equity.

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