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Electricity demand and basic needs: Empirical evidence from China's households

Xiaoping He [a,*], David Reiner [b]

[a] Collaborative Innovation Center for Energy Economics and Energy Policy, School of Economics, Xiamen University, Xiamen City 361005, China
[b] Energy Policy Research Group, Judge Business School, University of Cambridge, Trumpington Street, Cambridge CB2 1AG, UK

HIGHLIGHTS

- Basic electricity needs of a household are investigated with survey data.
- The Basic electricity needs differ between the rural and urban households.
- The first block of the IBTs in China has proven too high and beyond the basic needs.
- The initial policy targets of the IBTs in China will be difficult to achieve.

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ABSTRACT

An increasing block tariff (IBT) has been implemented nationwide in the residential sector in China since 2012. However, knowledge about IBT design is still limited, particularly how to determine the electricity volume for the first block of an IBT scheme. Assuming the first block should be set based on some measure of electricity poverty; we attempt to model household electricity demand such that the range of basic needs can be established. We show that in Chinese households there exists a threshold for electricity consumption with respect to income, which could be considered a measure of electricity poverty, and the threshold differs between rural and urban areas. For rural (urban) families, electricity consumption at the level of 7th (5th) income decile households can be considered the threshold for basic needs or a measure of electricity poverty since household electricity demand in rural (urban) areas does not respond to income changes until after 7th (5th) income decile. Accordingly, the first IBT block for some provinces (e.g., Beijing) appears to have been set at a level that is too high. Over time however, given continued rapid growth, the IBT will begin to better reflect actual basic needs.

1. Introduction

Over the past three decades, China's economic growth has driven rapid increases in electricity consumption. Between 1980 and 2012, electricity consumption in China increased at an annual growth rate of 9.2%. Over the same period, electricity demand in the residential sector, accounting for 13.3% of total electricity consumption, grew at an even faster rate of 12.0%.[1] Retail electricity prices are tightly controlled by the Chinese government and have long been kept at artificially low levels (Lin and Jiang, 2011, 2012). Moreover, electricity consumption in the residential sector is cross-subsidized by the industrial and commercial sectors, and retail prices for residential electricity are usually lower than its long-term marginal cost (Lin and Jiang, 2011). Reform towards cost-reflective tariffs has proven difficult because of concerns that increasing prices may impact the welfare of poor households and, as such, electricity prices are politically sensitive. Whereas electricity prices are subject to strict controls, the coal price has been liberalized since 1992. As a result, any cost increases borne by electricity producers could not be transferred to end users because of price controls (Wang, 2007). Moreover, the price dual-track for coal and electricity resulted in many disputes between the two industries and supply disruptions in many areas of the country.

Given the untenable situation, the Chinese government has begun to promote electricity price reforms. One reform measure is the increasing block tariff (IBT), which has been implemented nationwide in the residential sector since July 2012, so as to eventually reduce electricity cross subsidies and promote efficient

* Corresponding author.
E-mail addresses: xphe@xmu.edu.cn (X. He), dmr40@cam.ac.uk (D. Reiner).
[1] This is authors' calculation, based on original data provided by NBS (2014).

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use of electricity. IBT, a nonlinear pricing method[2] comprising a rising set of charges as consumption increases, has often been promoted as a solution, for multiple social (and/or financial) targets, such as equity, cost recovery, and environmental concerns. The nonlinearity of IBT implies that the expenditure on electricity is not linearly proportional to consumption. Under an IBT scheme, household electricity consumption can be divided into several blocks, and a prescribed price applied to each defined block. In theory, IBT has the capability of achieving economic efficiency and social equity simultaneously while enabling cost recovery by utilities. However, in practice, its effect depends largely on the details of the scheme. For example, a large volume of electricity in the initial block with a subsidized price might result in excessive subsidies. Although IBT has been the subject of considerable attention recently in China, knowledge about IBT design is still limited, particularly how to determine the rate and the electricity quantity for the first block of an IBT scheme.

In developing countries, the first block of IBT has usually been set at a subsidized price, with a nominal goal of ensuring the poor can pay for some minimum volume of energy services to perform such basic tasks as cooking, lighting and heating at an affordable price (usually described as a "lifeline" tariff). The philosophy behind lifeline rates is that electricity is a necessity in modern society and every family should be able to purchase enough electricity to meet its minimum needs without undue budgetary stress (Petersen, 1982). It is obvious that the ability of the IBT to deliver social equity on its promise of effectively targeting the poor depends on setting the volume of electricity in the initial block equal to the basic electricity needs. If a high volume be set, wealthier households would get more benefits from the low price. Therefore, if it is the case that "every family should be able to purchase enough electricity to meet its minimum needs", one empirical question concerning IBT is to model the household electricity demand such that the size of the minimum-need block can be established.

Based on a dataset drawn from a survey of three provinces in China, we attempt to define and quantify the basic electricity needs of rural and urban households, using the measurement for "energy poverty" developed by Khandker et al. (2010). To our knowledge, no study has examined the basic electricity needs of households in China. To be specific, the first studies of IBT in China have mostly set the electricity volume of each block at a pre-determined level, rather than basing it on a quantitative analysis. Such an example is the study by Lin and Jiang (2012), who suggested setting the first block in the IBT scheme based on the "lifeline volume", and setting the second block to meet the "basic demand" of low-income households. In other studies, lifeline rates were usually based on either "essential needs" (Petersen, 1982; Hennessy, 1984) or "basic needs" (Wodon et al., 2003).

We attempt to establish a single measure of basic needs rather than distinguishing between "lifeline" needs and essential (or basic) needs. We provide an estimate of basic needs for electricity in Chinese households, but our primary purpose is to provide a conceptual discussion regarding how household electricity demand should be defined and measured. Our results have clear policy implications and provide empirical evidence to help improve the IBT scheme in China. The remainder of our study is organized as follows: in Section 3, we discuss household electricity consumption patterns in China. In Section 4, we present the analytical framework for defining and measuring households' basic needs for electricity, using a demand-based approach and drawing on a definition of "energy poverty". In Section 5, we empirically investigate household electricity consumption in China, specifically how electricity consumption responds to the changes in income. Conclusions and policy implications are given in the final section.

2. Electricity consumption of Chinese households

Energy consumption patterns (and lifestyles) of Chinese households have changed drastically with rapidly rising income over the past three decades. In the 1980s, China's residential electricity consumption was almost entirely used for lighting. Since the 1990s, electricity has become one of the principal energy sources for recreation and social communication, being used for televisions, computers, DVD players, and audio systems, in addition to more 'basic' forms such as lighting, cooking, washing, cooling and heating. Lin and Jiang (2012) estimated that in the electricity consumption of urban low-income households, electricity used for recreation accounted for 18% (only televisions are considered). Though no further information on consumption patterns of other income groups is available, it is reasonable to assume that wealthier urban households would use more electricity for recreation. In rural areas, electricity is used not only for daily life but also for production, such as in home workshops. The energy used for productive activities accounted for more than 50% of rural residential energy consumption over the past twenty years (NBS, 2011a, 2013a), mainly in the form of coal, electricity and diesel. Although exact figures for electricity used as productive input is not available, its proportion in energy consumption of rural families must logically be quite significant.

Because we will have to use data from 2009 for our econometric analysis in Section 4 , the data cited in this section are for 2009 to make it easier to compare, unless otherwise stated. The change between 2009 and 2012 well illustrate the dramatic increase in electricity consumption in just three years. During this period, total electricity consumption of China increased from 3703 to 4976 TW h, a growth rate of over 10% per annum. The proportion of residential consumption in total electricity consumption has held steady at about 13%, which is much lower than that of industry (about 73%). Meanwhile, in the residential sector, electricity consumption per capita has grown from 365 to 459 kW h (or 8% growth per annum).[3]

In 2009, per capita residential electricity consumption in rural and urban areas was 296 kW h and 439 kW h,[4] respectively. As a share of residential end-use energy consumption, electricity accounts for 25.9%, just behind coal at 29.5%. In rural areas, coal is still the most popular source of energy because of its availability and convenience, in addition to the low penetration of petroleum products and gas. The share of coal in energy consumption for rural households is as much as 57.7%, compared to 11.2% in urban areas.

In some rural areas, a variety of non-commercial energy sources, such as straw, firewood, biogas and solar, are still popular, mainly for cooking. Generally speaking, as income levels of rural

[2] There are various pricing methods for public utilities, depending on the policy objective. The marginal cost pricing (MCP), largely targeting economic efficiency, is a typical linear method and has been widely used in utilities. With the MCP, the price per unit of service/product remains unchanged with increasing quantity of the consumption. However, linear pricing is usually not optimum when there are multiple policy objectives. Some nonlinear pricing methods such as two-part tariff (Coase, 1946) and block tariff have the advantage of meeting multiple targets. For instance, a two-part tariff is composed of fixed fee and service charge, and can be used to compensate the fixed cost (therefore meet the financial target), and as well, the marginal cost (hence to meet the efficiency target). If a nonlinear price scheme has more than two price blocks, it is known as the block tariff.

[3] These are calculated by the authors, according to original data provided by NBS (2011b, 2014).

[4] These figures are calculated by authors and based on data from NBS (2011a, 2011b).