

Article

The Impact of the Implementation Cycle of Increasing-Block Tariffs on Residential Electricity Consumption in China

Yongfei Wu, Hanqi Yang * and Yang Gao

School of Economics & Management, Changsha University of Science & Technology, Changsha 410004, China; wuyongfei@csust.edu.cn (Y.W.); gaoyang2023@csust.edu.cn (Y.G.)

* Correspondence: 17307377508@163.com

Abstract

As China advances price reform and modernizes its governance system, the optimization of residential increasing-block tariffs (IBT) has received increasing policy attention. Using data from the China Family Panel Studies (CFPS), this paper employs a multi-period difference-in-differences (DID) model to examine the impact of changing the implementation cycle of increasing-block tariffs from monthly to annual on residential electricity consumption. The results show that extending the billing cycle significantly increases residential electricity consumption. Mechanism analysis indicates that annual implementation smooths monthly consumption fluctuations, reduces the probability of entering higher tariff tiers, and lowers the average effective electricity price, thereby weakening households' sensitivity to marginal electricity prices and increasing electricity use. Heterogeneity analysis further shows that this effect is mainly concentrated among low-income and less-educated households. These findings suggest adopting a hybrid policy combining monthly implementation with seasonal tier design to improve price signal clarity and enhance both efficiency and equity.

Keywords: increasing-block tariffs; implementation cycle; residential electricity consumption; multi-period DID

1. Introduction

Improving the price governance mechanism and optimizing the residential increasing-block electricity tariffs (IBT) system have become important policy instruments for deepening price reform and safeguarding public welfare. The Decision on Further Deepening Reform to Advance Chinese Modernization issued by the Central Committee of the Communist Party of China on 18 July 2024, and the Opinions on Improving the Price Governance Mechanism jointly issued by the General Office of the CPC Central Committee and the General Office of the State Council on 5 December 2024, both explicitly call for “optimizing the residential IBT system” and incorporate it into the broader reform framework of electricity tariff mechanisms and resource allocation.

Against this background, how IBT can simultaneously promote energy conservation while maintaining fairness and affordability has become a key concern in both theory and practice. The residential IBT system is not uniform across provinces. In addition to regional differences in tiered consumption levels and tariff rates, a more important difference lies in billing cycles. Some provinces (municipalities) implement IBT on an annual basis, while others adopt a monthly cycle, and in some cases, the implementation has

Academic Editor: Jay Zarnikau

Received: 27 May 2026

Revised: 10 July 2026

Accepted: 22 July 2026

Published: 24 July 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

shifted from monthly to annual. For example, Guizhou, Hubei, Guangxi, and Chongqing have successively adjusted the implementation cycle of residential IBT from monthly to annual. This suggests that the shift from monthly to annual billing represents an observable path of institutional evolution. At the same time, in regions adopting annual implementation, public concern over electricity bills has increased, particularly the perception and discussion of “substantially higher year-end electricity bills”. For instance, in Shanghai, residents have reported noticeably higher electricity charges at year-end, which even triggered official responses. This phenomenon is closely related to IBT mechanisms, such as cumulative annual electricity consumption crossing higher tiers. These observations suggest that the billing cycle not only affects how electricity bills are presented but may also reshape residents’ perception of price signals and their behavioral responses.

From the perspective of policy objectives, promoting electricity conservation and guiding rational electricity use are among the core goals of the IBT system. IBT is characterized by increasing marginal electricity prices, whereby higher levels of electricity consumption correspond to higher marginal prices, thereby discouraging excessive electricity consumption and promoting energy-saving behavior through price signals. Therefore, when the implementation cycle shifts from monthly to annual, a key question arises: can IBT still effectively constrain electricity consumption? Furthermore, one policy rationale for shifting from monthly to annual implementation is to reduce the average effective electricity price faced by households, reduce short-term payment burdens, and smooth fluctuations in electricity bills caused by tier transitions. However, such an institutional adjustment, which aims to “reduce perceived electricity prices and smooth billing fluctuations,” may unintentionally weaken the marginal constraint effect of IBT. This raises a critical question as to whether the reform represents a balanced optimization between welfare improvement and energy conservation or instead constitutes a relaxation of policy constraints that may stimulate additional electricity consumption.

In response to the above practical debate, this paper focuses on the following core question: whether the shift in residential IBT from monthly to annual implementation is beneficial, and by what criteria its effects should be evaluated. Different from studies that focus solely on electricity price levels or household electricity expenditure, this paper defines the issue as a comprehensive assessment of the policy objectives of IBT and addresses two key aspects. First, whether the shift from monthly to annual implementation achieves the goal of electricity conservation, or instead leads to an increase in residential electricity consumption. Second, whether behavioral responses exist, whether they arise from the reshaping of price signals caused by the extension of the billing cycle, and whether such effects exhibit systematic heterogeneity across different groups. To address these questions, this paper uses data from the China Family Panel Studies (CFPS) and exploits temporal and regional variations in policy implementation cycles. A multi-period difference-in-differences (DID) approach is employed to identify the causal effect of shifting from monthly to annual implementation on residential electricity consumption. Furthermore, this paper conducts a mechanism analysis from the perspective of price signal transmission. Specifically, it examines how extending the billing cycle affects electricity consumption decisions by smoothing monthly consumption fluctuations, altering the probability of crossing tariff tiers, and changing the average effective electricity price. In addition, heterogeneity analysis is performed across household income and education levels to characterize the distributional effects and potential equity implications of the policy. The marginal contributions of this paper are threefold. First, by focusing on the implementation cycle—an often overlooked yet critically important institutional detail—this study extends the analytical perspective of IBT policy evaluation beyond tier thresholds and tariff levels to the institutional mechanisms of signal frequency and constraint intensity. Second, it provides empirically testable evidence on the formation and transmission of

price signals, linking the shift from monthly to annual billing to an identifiable behavioral mechanism. Third, by identifying stronger behavioral responses among low-income and less-educated groups, the study provides micro-level evidence for understanding the trade-off between energy efficiency and equity effects in IBT reform and provides evidence for future policy design.

The main contributions of this study are summarized as follows.

1. Existing studies on IBT mainly focus on tariff structures, tier thresholds, and pricing levels, while limited attention has been paid to the implementation cycle as an important institutional arrangement. This study extends the analytical framework of IBT by incorporating the implementation cycle as an important institutional dimension and examining its impact on residential electricity consumption.
2. Using temporal and regional variations in the transition from monthly to annual implementation as a quasi-natural experiment, this study employs a multi-period difference-in-differences (DID) model based on CFPS data to identify the causal effect of implementation cycle changes on household electricity consumption, thereby providing new empirical evidence for IBT policy evaluation.
3. This study explores the behavioral mechanism through which implementation cycle changes affect electricity consumption. The results reveal that annual implementation smooths monthly consumption fluctuations, reduces the probability of entering higher tariff tiers, lowers the average effective electricity price, and ultimately increases residential electricity consumption.
4. This study identifies significant heterogeneity in policy effects across household groups. The consumption-promoting effect of annual implementation is found to be more pronounced among low-income and less-educated households, providing new evidence for balancing energy efficiency and equity objectives in electricity pricing reform.

2. Literature Review

Increasing-block tariffs (IBT) have been widely studied in both domestic and international literature. Existing studies mainly focus on two aspects:

2.1. Research on the Optimal Design of IBT

First, existing studies examine different types of IBT systems. These systems mainly include increasing-block and decreasing-block tariff structures [1,2]. Increasing-block tariffs are currently the most widely adopted form. For example, countries and regions such as China, the United States, and India have adopted this model [3,4]. Its typical feature is to divide electricity consumption into basic, intermediate, and high-consumption tiers, with electricity prices increasing progressively across tiers [5–8]. This structure is considered effective in promoting energy conservation and improving equity [9]. In contrast, decreasing-block tariff is mainly used in regions with abundant electricity resources and policies that encourage electricity consumption. Under this model, higher electricity consumption corresponds to lower electricity prices, thereby lowering electricity costs for consumers. At present, it is only adopted in a few resource-rich countries, such as Norway and some provinces in Canada [7,10,11].

Second, there are studies on the parameter design of IBT. The core of residential IBT design lies in three key parameters: the number of tiers, the electricity consumption thresholds, and the tariff levels for each tier. Regarding the number of tiers, the number of tiers determines the corresponding thresholds and tariff levels [7,12–14]. At present, China adopts a three-tier IBT system across all provinces. However, this design is largely based on experience, and its suitability remains debated [13,14]. Based on cross-country

empirical analysis, the number of tiers generally ranges from two to eight, and developed countries tend to have fewer tiers than developing countries. In addition, the determination of the number of tiers should take into account factors such as regional economic development level, household electricity consumption patterns, climate conditions, tariff multiples, and average electricity prices [7]. Unlike the uniform three-tier structure currently adopted across China, the optimal number of tiers should vary by region, with 2–3 tiers being most appropriate, depending on regional household conditions [14]. With respect to the selection of tiered consumption thresholds, there is a general consensus that setting reasonable thresholds is a key component of implementing IBT policies and can effectively help achieve multiple policy objectives [15–18]. However, there is considerable disagreement on specific threshold levels. From the perspective of coverage targets, the first-tier threshold has been set too high, exceeding the national target of 80%. Reducing the first-tier threshold and expanding seasonal tier design have been proposed [10,16,17]. In contrast, from the perspectives of income redistribution, mitigation of cross-subsidies, and energy conservation, the first-tier threshold is too low while the second-tier threshold is too high [14,18]. This conclusion is further supported by studies incorporating personal carbon trading mechanisms, which finds that households can adjust their income through carbon trading, leading to an increase in the second-tier threshold and a decrease in the third-tier threshold [19]. Regarding the setting of IBT levels, existing studies can be broadly divided into two approaches: cost-oriented and demand-oriented methods. The former optimizes tariff levels through cost allocation, for example, by considering electricity load characteristics in cost allocation when determining IBT levels [20]. The latter approach optimizes tariff levels based on consumer price elasticity to achieve energy conservation and alleviate cross-subsidies [6,21]. Nevertheless, the mainstream view holds that the current tariff levels in residential IBT are relatively low and require further optimization [14,21].

Finally, there are studies on the coordination between residential IBT and other electricity tariff systems. Most studies find that there are conflicts between IBT and time-of-use pricing, making it difficult to improve tariff efficiency and promote fairness [22–24]. Meanwhile the temporal characteristics, such as seasonal patterns and the timing of price signal transmission, may affect the effectiveness of electricity pricing mechanisms [25].

2.2. Policy Effect Evaluation of Increasing-Block Tariffs

The evaluation of residential increasing-block tariffs (IBT) mainly focuses on three core objectives: energy conservation effects, income redistribution effects, and the mitigation of cross-subsidies [18,26,27]. To begin with, regarding energy conservation effects, most studies affirm its positive impact. IBT reform can guide household electricity consumption behavior, significantly reduce electricity usage, and achieve the goal of energy conservation [28–30]. Using household-level data and an instrumental variable approach, recent studies further confirm that IBT can effectively reduce residential electricity consumption, particularly among high-income households, providing additional evidence for the energy-conservation effect of the policy [29]. Moreover, evidence based on nationally representative CFPS household data shows that increasing-block pricing significantly reduces residential electricity consumption and exhibits heterogeneous effects across different household groups and regions, further supporting the effectiveness of the policy in promoting energy conservation [31]. In addition, the implementation of IBT has a positive effect on improving residents' willingness to conserve energy [32]. The IBT structure can effectively restrain irrational electricity consumption, and higher tariff levels across tiers lead to stronger electricity-saving effects. In addition, regarding the mitigation of cross-subsidies, it is generally believed that IBT can reduce the scale of cross-subsidies [21]. It may even achieve internal cross-subsidization among residential users through IBT,

thereby alleviating price distortions [20,21,32]. It is suggested that using the higher revenues from the third tier to subsidize the lower-cost basic tier helps reduce the extent of subsidies from industrial users to residential users, while also taking into account the welfare of low-income households [6,26]. However, the extent of this improvement is relatively limited [32]. Finally, in terms of income redistribution, IBT exhibits a dual effect. On the one hand, the progressive nature of IBT leads high-income households with higher electricity consumption to bear greater expenditures, thereby facilitating a certain degree of redistribution from the rich to the poor and helping reduce income inequality [33]. On the other hand, IBT may generate a rebound effect. For some low-income households whose electricity consumption already exceeds the baseline tier, the policy may instead impose additional financial burdens, thereby weakening its redistribution effect [34,35].

Overall, the existing literature has formed a relatively systematic research framework on the optimal design and policy effect evaluation of IBT. However, there remains room for further extension. First, most existing studies focus on explicit design parameters, such as the number of tiers, tiered consumption thresholds, and tariff levels, while paying insufficient attention to the implementation cycle, a critical institutional detail. As the carrier of the frequency of policy signal release and the transmission medium of constraint intensity, the implementation cycle directly affects the decision-making logic of residential electricity consumption. Incorporating this dimension into the analytical framework can effectively expand the research perspective on IBT policy evaluation, shifting the discussion from static parameter design to dynamic institutional mechanisms, and revealing the internal logic through which signal frequency and constraint intensity influence household electricity consumption behavior. Second, existing studies lack in-depth exploration of the behavioral mechanisms underlying changes in the implementation cycle of IBT. This study provides testable evidence on the formation and transmission of price signals, elevating the adjustment of the implementation cycle from a purely practical policy operation to an interpretable and verifiable behavioral mechanism. By analyzing how price signals are perceived, interpreted, and translated into changes in electricity consumption behavior under different implementation cycles, this study offers a new theoretical perspective and empirical basis for the refined optimization of IBT policies, and contributes to the transition from “parameter optimization” to “institutional optimization” in policy design.

3. Theoretical Model Derivation

3.1. Consumer Utility and Electricity Expenditure Function

Annual electricity consumption utility is the sum of monthly utilities: $U = \sum_{t=1}^{12} u(q_t)$, where q_t denotes electricity consumption in month t , satisfying the annual consumption constraint $Q = \sum_{t=1}^{12} q_t$; $u_t(q_t)$ represents the utility function in month t . The utility functions are allowed to vary across months to reflect differences between high- and low-demand periods. Marginal utility is positive and diminishing: $u'_t(q_t) > 0, u''_t(q_t) < 0$.

Under China's current IBT scheme, electricity tariffs are divided into three tiers with prices p_1, p_2 and p_3 , unchanged under both annual and monthly implementation. The key difference lies in the tier thresholds: annual thresholds are 12 times the monthly ones, i.e., ($K_1 = 12k_1, K_2 = 12k_2$); Accordingly, the billing rules under the two implementation schemes are given by Equations (1) and (2).

The electricity expenditure under monthly implementation can be expressed as:

$$C_t^{month}(q_t) = \begin{cases} p_1 q_t & q_t \leq k_1 \\ p_1 k_1 + p_2 (q_t - k_1) & k_1 < q_t \leq k_2 \\ p_1 k_1 + p_2 (k_2 - k_1) + p_3 (q_t - k_2) & q_t > k_2 \end{cases} \quad (1)$$

where $C_t^{month}(q_t)$ denotes the electricity expenditure in month t , k_1 and k_2 represent the tier thresholds between the first and second tiers, and between the second and third tiers under monthly implementation, respectively.

The electricity expenditure under annual implementation can be expressed as:

$$C^{annual}(Q) = \begin{cases} p_1 Q & Q \leq K_1 \\ p_1 K_1 + p_2 (Q - K_1) & K_1 < Q \leq K_2 \\ p_1 K_1 + p_2 (K_2 - K_1) + p_3 (Q - K_2) & Q > K_2 \end{cases} \quad (2)$$

where $C^{annual}(Q)$ denotes the electricity expenditure in whole year, K_1 and K_2 represent the tier thresholds between the first and second tiers, and between the second and third tiers under monthly implementation, respectively.

3.2. Optimal Monthly Electricity Consumption Under Monthly Billing Scheme

From the utility and tariff functions, the consumer's net utility is:

$$V(q_t) = u_t(q_t) - C_t^{month}(q_t) \quad (3)$$

The first-order condition $V'(q_t) = u'_t(q_t) - C_t^{month'}(q_t) = 0$ implies that marginal utility equals marginal cost. Under IBT, the marginal cost differs across blocks:

$$MC = \begin{cases} p_1 & q_t \leq k_1 \\ p_2 & k_1 < q_t \leq k_2 \\ p_3 & q_t > 12k_2 \end{cases} \quad (4)$$

Under the increasing-block tariff structure, the theoretical optimum under a given tariff tier may exceed the corresponding tier threshold. In such cases, the actual optimal consumption must be jointly determined by marginal utility and the applicable tariff schedule. Therefore, the optimal monthly electricity consumption depends on the interaction between household demand and the tiered pricing structure. The detailed case analysis and mathematical derivation are provided in Appendix A.

The final optimal monthly electricity consumption is determined as:

$$q_t^{month} = \begin{cases} q_t^1 & q_t^1 \leq k_1 \\ k_1 & q_t^2 \leq k_1 < q_t^1 \\ q_t^2 & k_1 < q_t^2 \leq k_2 \\ k_2 & q_t^3 \leq k_2 < q_t^2 \\ q_t^3 & q_t^3 > k_2 \end{cases} \quad (5)$$

Given the annual electricity consumption $Q^{month} = \sum_{t=1}^{12} q_t^{month}$, monthly quota constraints may become binding during peak-demand months, preventing households from fully utilizing the annual tariff allowance. Consequently, total annual electricity consumption under monthly implementation may be lower than that under annual implementation.

3.3. Optimal Electricity Consumption Under Annual Implementation

Since the IBT is implemented on an annual basis, the net utility function needs to be aggregated over the year. The objective is to maximize the total annual net utility function, which is given by:

$$\max_{\{q_1, \dots, q_T\}} \sum_{t=1}^T u_t(q_t) - C\left(\sum_{t=1}^T q_t\right) \quad (6)$$

Let the total electricity consumption be $Q = \sum_{t=1}^T q_t$. Accordingly, the Lagrangian function is introduced as:

$$L = \sum_{t=1}^T u_t(q_t) - C(Q) + \lambda \left(Q - \sum_{t=1}^T q_t \right) \quad (7)$$

Intertemporal optimality gives $\frac{\partial L}{\partial q_t} = u'_t(q_t) - \lambda = 0 \Rightarrow u'_t(q_t) = \lambda$, so marginal utility is equalized across months. This holds regardless of whether monthly utilities are identical, implying that monthly consumption levels need not be equal: high-demand months have higher consumption than low-demand months ($q_t^* > q_s^*$, where t and s denote high- and low-demand months, respectively). Thus the optimal annual consumption Q corresponds to a set of monthly levels $\{q_t^*\}$ that satisfy this equalization condition. Combined with the earlier analysis of optimal monthly consumption, the optimal annual electricity consumption is given by:

$$Q^* = \begin{cases} Q^1 & Q^1 \leq K_1 \\ K_1 & Q^2 \leq K_1 < Q^1 \\ Q^2 & K_1 < Q^2 \leq K_2 \\ K_2 & Q^3 \leq K_2 < Q^2 \\ Q^3 & Q^3 > K_2 \end{cases} \quad (8)$$

3.4. Comparison of Electricity Consumption Under Different IBT Implementation Modes

3.4.1. “Equivalent Monthly Optimal Electricity Consumption” Under Annual Implementation and Its Annual Utility Function

For any Q , optimal monthly allocation $\{q_t^*(Q)\}$ satisfies $\sum_{t=1}^T q_t^*(Q) = Q$. Intertemporal reallocation allows higher consumption in high-demand months and lower in low-demand months, with equalized marginal utility: $u'_t(q_t^*(Q)) = \lambda(Q)$, where $\lambda(Q)$ is the marginal utility for Q . Therefore, the net utility under annual implementation can be expressed as:

$$V(Q) = \sum_{t=1}^T u_t(q_t^*(Q)) - C(Q) \quad (9)$$

Concavity of u_t and convexity of $C(Q)$ imply $V(Q)$ strictly concave, yielding unique maximum at $Q^* = \sum_{t=1}^T q_t^*$. Here q_t^* (from intertemporal optimization, distinct from q_t^{month}) satisfies $V'(Q^*) = 0$.

3.4.2. Optimal Monthly Electricity Consumption Under Monthly Implementation and the “Annualized Net Utility Function”

Under monthly implementation, each month’s consumption q_t^{month} is independently chosen to satisfy marginal utility equals current marginal cost. The core feature is independent monthly optimization with no intertemporal allocation: each month considers only its IBT structure and own utility $u_t(q)$. The resulting annual total is $Q^{month} = \sum_{t=1}^T q_t^{month}$. According to Jensen’s inequality for concave functions:

$$\frac{f(x_1) + f(x_2) + \dots + f(x_n)}{n} \leq f\left(\frac{x_1 + x_2 + \dots + x_n}{n}\right) \quad (10)$$

Under the same level of annual total electricity consumption, the utility under annual implementation is higher, i.e.,

$$\sum_{t=1}^T u_t(q_t^{month}) \leq \sum_{t=1}^T u_t(q_t^*(Q^{month})) \quad (11)$$

Meanwhile, under the same level of total electricity consumption, annual implementation avoids the situation in which a single month exceeds the quota and triggers a higher tariff. As a result, total electricity expenditure under annual IBT is lower. Therefore, under the condition of equal total electricity consumption, total electricity expenditure under monthly and annual implementation satisfies:

$$\sum_{t=1}^T c(q_t^{month}) \geq C(Q^{month}) \quad (12)$$

Therefore, the net utility under monthly implementation can be expressed as:

$$V^{month} = \sum_{t=1}^T [u_t(q_t^{month}) - c(q_t^{month})] \leq V(Q^{month}) = \sum_{t=1}^T u_t(q_t^*(Q^{month})) - C(Q^{month}) \quad (13)$$

3.4.3. Monotonicity of the Optimal Solution Under Annual Implementation and Its Relationship with Electricity Consumption

Since $V(Q)$ is strictly concave, its marginal utility $V'(Q)$ is strictly decreasing. When $Q < Q^*$, $V'(Q) > 0$, indicating that increasing electricity consumption raises net utility; when $Q > Q^*$, $V'(Q) < 0$, indicating that additional consumption reduces net utility. Therefore, if $Q^{month} \leq Q^*$, then $V'(Q^{month}) \geq 0$, and under annual implementation, net utility can be further increased by raising electricity consumption until Q^* , implying $Q^* \geq Q^{month}$. Conversely, if $Q^{month} > Q^*$, then $V'(Q^{month}) < 0$, so reducing electricity consumption increases net utility, implying $V(Q^*) > V(Q^{month})$. Combined with Equation (13), this yields $V^{month} \leq V(Q^{month}) < V(Q^*)$ which contradicts the optimality of Q^{month} under monthly implementation, because the monthly solution is obtained through month-by-month optimization and therefore cannot be improved by further adjusting total electricity consumption. Hence, the case $Q^* < Q^{month}$ cannot occur, and it follows that $Q^* \geq Q^{month}$. This demonstrates that total electricity consumption under annual implementation is greater than or equal to that under monthly implementation.

3.5. Comparison of Cross-Subsidization Under Different Implementation Modes of IBT

Electricity price cross-subsidization refers to a situation in which residential electricity tariffs are lower than the actual supply cost, and the resulting cost gap must be covered by other users (e.g., industrial and commercial consumers). Therefore, for any implementation mode of IBT, total subsidy is defined as total supply cost minus residential electricity revenue, which can be expressed as:

$$S = c_0 Q_{total} - \text{Total electricity revenue} \quad (14)$$

where c_0 denotes the per-unit electricity supply cost; Q_{total} represents total residential electricity consumption (which is Q^* under annual implementation and Q^{month} under monthly implementation); total residential electricity expenditure is $C(Q^*)$ under annual implementation and $\sum_{t=1}^T c(q_t^{month})$ under monthly implementation.

Based on the theoretical model developed above, annual implementation not only increases household electricity consumption but also increases the magnitude of cross-subsidization under the IBT system. This result follows from two mechanisms. First, higher electricity consumption under annual implementation increases the total amount of subsidized electricity consumption. Second, annual implementation allows households to allocate electricity consumption more efficiently across months, increasing the share of electricity billed at lower tariff blocks and thereby enlarging the overall cross-subsidization.

Accordingly, the theoretical model predicts that:

$$S^* \geq S^{month} \quad (15)$$

The detailed mathematical derivation is presented in Appendix B.

Based on the above theoretical results, the following testable predictions are proposed and are examined in the empirical analysis.

1. Annual implementation of IBT is expected to increase household electricity consumption. This prediction is evaluated in the baseline DID analysis.

2. Annual implementation is expected to reduce households' exposure to higher tariff blocks, thereby lowering the effective electricity price and increasing electricity consumption.
3. The policy effect is expected to be stronger for low-income and low-education households because these households are more sensitive to electricity price changes. This prediction is tested in the heterogeneity analysis.

4. Increasing-Block Tariffs Reform Policy

Since 2004, IBT has been gradually introduced in Zhejiang, Fujian, and Sichuan provinces, all under a monthly billing scheme. Among them, Zhejiang Province officially implemented IBT in August 2004. In Fujian Province, IBT for residential electricity in areas directly supplied by the provincial power grid was introduced in October 2004. In July 2006, IBT was implemented province-wide to alleviate electricity price distortions, support relocated reservoir migrants, and promote renewable energy development.

On 9 October 2010, the National Development and Reform Commission (NDRC) officially released the “Guiding Opinions on Implementing IBT for Residential Electricity (Draft for Public Comments),” soliciting feedback from the public. The majority of responses supported the residential IBT mechanism and the direction of electricity price reform. It was widely recognized that, amid growing energy supply constraints and environmental pressures, the implementation of residential IBT was necessary to enhance energy conservation awareness at the societal level and to promote resource conservation, environmental protection, and energy-efficient technological progress. After extensive investigation and repeated feasibility assessments, the NDRC formally issued the “Guiding Opinions on the Trial Implementation of IBT for Residential Electricity” in December 2011. On 28 March 2012, at the National Economic System Reform Work Conference, the NDRC announced that residential IBT would be introduced in the first half of 2012. By mid-June of the same year, provincial governments successively released their implementation plans. Starting from 1 July 2012, residential IBT was officially implemented across 29 provinces and municipalities nationwide (excluding Xinjiang, Tibet, Hong Kong, Macao, and Taiwan). All regions adopted a three-tier structure—classified as basic necessity consumption, normal reasonable consumption, and high-quality living consumption—with electricity prices increasing progressively across tiers.

There are two implementation schemes for residential IBT: annual and monthly billing cycles. As shown in Table 1, 15 provinces and municipalities, including Ningxia, Heilongjiang, and Jilin, initially adopted an annual billing cycle for IBT and have maintained this arrangement ever since. Under this scheme, the threshold for the first and second tiers ranges from 2040 to 3120 kWh per year, while the threshold between the second and third tiers ranges from 3121 to 4800 kWh per year. The price for the second tier is uniformly 0.05 CNY/kWh higher than the first tier, while the third-tier price is uniformly 0.30 CNY/kWh higher than the first tier. In contrast, 14 provinces and municipalities, including Fujian, Sichuan, Yunnan, Guangdong, and Hunan, adopted a monthly billing cycle to shift residential electricity consumption away from peak-demand seasons and to avoid the concentration of higher-tier electricity consumption in the third and fourth quarters of the year. At the same time, this design also imposes tighter constraints on highly mobile households. Under this scheme, the threshold for the first and second tiers ranges from 120 to 200 kWh per month, while the threshold between the second and third tiers ranges from 230 to 400 kWh per month. The second-tier price is set at 0.05 CNY/kWh above the first-tier price (except in Sichuan Province, where the increment is 0.10 CNY/kWh), and the third-tier price is uniformly 0.30 CNY/kWh above the first-tier price. Some provinces and municipalities later shifted from monthly to annual billing after initially adopting the monthly scheme, including Guizhou, Hubei, Guangxi, and Chongqing, which changed

their billing cycles in January 2014, January 2015, July 2015, and January 2016, respectively. However, the monthly equivalent tier thresholds and price differentials remained unchanged after the conversion. These provinces form the treatment group in the empirical analysis. Although several provinces initially adopted monthly billing to accommodate seasonal electricity demand fluctuations, subsequent transitions to annual billing were implemented during the continued refinement of the residential IBT system. Official policy documents from Guizhou and Chongqing indicate that these adjustments aimed to improve the implementation of the residential IBT system, reduce distortions arising from monthly tariff assessment, and enhance the flexibility of annual electricity allocation [36,37]. Nevertheless, we acknowledge that province-specific policy considerations may have been correlated with local electricity demand conditions. Therefore, the possibility of demand-related policy selection cannot be completely excluded. To address this concern, this study employs household fixed effects, year fixed effects, parallel trend tests, placebo tests, and multiple robustness checks to verify the reliability of the estimated effects.

Table 1. Table of Residential IBT Policies Implemented by Provinces and Cities.

Implementation Period	Provinces and Cities	Tiered Electricity Consumption and Price (kWh, CNY/kWh)					
		Tier 1		Tier 2		Tier 3	
		Electricity Consumption	Electricity Price	Electricity Consumption	Electricity Price	Electricity Consumption	Electricity Price
Implemented on a Monthly Basis	Yunnan	Up to 120	0.4670	121–250	0.5170	Above 250	0.8170
	Qinghai	Up to 150	0.3771	151–230	0.4271	Above 230	0.6771
	Gansu	Up to 160	0.5100	161–240	0.5600	Above 240	0.8100
	Hainan	Up to 160	0.4880	161–290	0.5380	Above 290	0.7880
	Shanxi	Up to 170	0.4770	171–260	0.5270	Above 260	0.7770
	Western Inner Mongolia	Up to 170	0.4300	171–260	0.4800	Above 260	0.7300
	Eastern Inner Mongolia	Up to 170	0.5000	171–260	0.5500	Above 260	0.8000
	Sichuan	Up to 180	0.5224	181–280	0.6224	Above 280	0.8224
	Hunan	Up to 180	0.5880	181–350	0.6380	Above 350	0.8880
	Fujian	Up to 200	0.4983	201–400	0.5483	Above 400	0.7983
After the Policy Changed from Monthly to Annual Implementation	Guangdong	Up to 200	0.6100	201–400	0.6600	Above 400	0.9100
	Guangxi	Up to 2040	0.5283	2041–3240	0.5783	Above 3240	0.8283
	Hubei	Up to 2160	0.5580	2016–4800	0.6080	Above 4800	0.8580
	Guizhou	Up to 2200	0.4556	2200–4000	0.5056	Above 4000	0.7556
	Chongqing	Up to 2400	0.5200	2401–4800	0.5700	Above 4800	0.8200
Implemented on an Annual Basis	Ningxia	Up to 2040	0.4486	2041–3120	0.4986	Above 3120	0.7486
	Heilongjiang	Up to 2040	0.5100	2041–3120	0.5600	Above 3120	0.8100
	Jilin	Up to 2040	0.5250	2041–3120	0.5750	Above 3120	0.8250
	Henan	Up to 2160	0.5600	2161–3120	0.6100	Above 3120	0.8600
	Liaoning	Up to 2160	0.5000	2161–3360	0.5500	Above 3360	0.8000
	Hebei	Up to 2160	0.5200	2161–3360	0.5700	Above 3360	0.8200
	Shaanxi	Up to 2160	0.4983	2161–4200	0.5483	Above 4200	0.7983
	Anhui	Up to 2160	0.5653	2161–4200	0.6153	Above 4200	0.8653
	Jiangxi	Up to 2160	0.6000	2161–4200	0.6500	Above 4200	0.9000
	Shandong	Up to 2520	0.5469	2520–4800	0.5969	Above 4800	0.8469
	Tianjin	Up to 2640	0.4900	2641–4800	0.5400	Above 4800	0.7900
	Jiangsu	Up to 2760	0.5283	2760–4800	0.5783	Above 4800	0.8283
	Zhejiang	Up to 2760	0.5380	2761–4800	0.5880	Above 4800	0.8380
	Beijing	Up to 2880	0.4883	2881–4800	0.5383	Above 4800	0.7883
	Shanghai	Up to 3120	0.6170	3120–4800	0.6670	Above 4800	0.9170

5. Research Design

5.1. Data Description and Variable Definitions

5.1.1. Data Sources

The data used in this study come from the 2012–2022 waves of the China Family Panel Studies (CFPS), the China Statistical Yearbook, and IBT schemes published by provincial (municipal) Development and Reform Commissions. The CFPS survey is conducted biennially and provides detailed household-level information across provinces and municipalities, including electricity consumption, actual electricity expenditure, annual household income, household size, urban–rural classification, and cooking fuel type. The IBT schemes released by provincial (municipal) Development and Reform Commissions are used to identify the treatment and control groups, as well as the tiered consumption thresholds and corresponding tariff levels. By matching these policy data with CFPS household-level electricity consumption and expenditure data, we further construct the household-level average effective electricity price. Provincial GDP and population data are obtained from the China Statistical Yearbook. The raw data are processed in three steps. First, household samples from provinces that implemented annual IBT from the outset in 2012 are excluded. Second, provinces in northern China that adopted monthly implementation schemes are removed (for two reasons: all treated provinces are located in southern China, and electricity consumption behavior in northern regions is structurally different due to heating demand). Third, observations with extreme household income values are dropped. In addition, samples with missing key variables are excluded. Finally, all continuous variables are winsorized at the 1% level to reduce the influence of outliers. After these procedures, a balanced household-year panel dataset containing 16,640 observations is constructed.

5.1.2. Variable Definitions

This study examines how the billing cycle of IBT affects electricity consumption, with particular attention to policy implementation status, electricity consumption levels, and effective electricity prices. To reduce potential omitted variable bias, household characteristics and macroeconomic factors are included as control variables. Table 2 summarizes the definitions of the main variables.

Table 2. Variable Definitions.

	Variable	Symbol	Variable Definition
Dependent Variable	Natural Logarithm of Electricity Consumption	$electricity_{ipt}$	Annual Electricity Consumption (kWh) of Household i in Province p in Year t
Independent Variable	Treatment Variable	$treat_{pt}$	IBT Implementation Period in Province p in Year t : assigned a value of 1 if policy $treat_{pt}$ is implemented on an annual basis from year t onwards; otherwise, assigned 0 (indicating monthly implementation)
	Time Variable	t_{it}	Assigned a value of 0 before the change in the IBT policy implementation period and 1 after the change
	Net Effect of IBT Implementation Period	DID	Net Policy Effect Represented by the Interaction Term of $t \times treat$
Control Variable	Natural Logarithm of Per Capita GDP	$lnprgdp_{pt}$	Log of Per Capita GDP in Province p in Year t : natural logarithm of the annual total GDP (100 million CNY) divided by population (10,000 people)
	Urban/Rural Attribute	$urban_{ipt}$	Urban/Rural Attribute of Household i in Province p in Year t : dummy variable, 1 for urban, 0 for rural

Natural Logarithm of Household Income	$\ln fincome_{ipt}$	Log of Household Income for Household i in Province p in Year t : Natural logarithm of total household income (CNY)
Household Size	$family size_{ipt}$	Household Size of Household i in Province p in Year t : total number of people in the household
Cooking Fuel Uses Electricity	or_elec_{ipt}	Cooking Fuel Uses Electricity for Household i in Province p in Year t : Dummy variable, 1 if household uses electricity for cooking, 0 otherwise

5.1.3. Descriptive Statistics

Table 3 presents the descriptive statistics. Missing household income values are imputed using provincial-level average income. The mean annual household electricity consumption is 2522 kWh. Comparison with Table 1 shows that the average household electricity consumption is located within the second-tier range of provincial electricity tariff schemes. The average per capita GDP is approximately CNY 52,920, which is broadly consistent with China's economic conditions during the sample period. The average household income is about CNY 79,101.34. The mean value of the urban–rural dummy variable is 0.516, and the average household size is approximately 4 persons. Except for the policy net effect of the billing cycle, the urban–rural indicator, household size, and whether cooking fuel is electricity, all other continuous variables are log-transformed for estimation.

Table 3. Descriptive Statistics.

Variable	Observations	Median	Variance	Minimum	Maximum
Natural Logarithm of Electricity Consumption	16,640	7.493	0.868	2.485	11.082
<i>DID</i>	16,640	0.151	0.358	0.000	1.000
Natural Logarithm of Per Capita GDP	16,640	1.573	0.438	0.464	2.325
Urban/Rural Attribute	16,640	0.516	0.500	0.000	1.000
Natural Logarithm of Household Income	16,640	10.643	1.222	6.685	13.181
Household Size	16,640	3.967	1.739	1.000	8.000
Whether electricity is used as cooking fuel	16,640	0.261	0.439	0.000	1.000

5.2. Model Specification

Since 1 July 2012, an IBT policy has been implemented nationwide in China, covering 29 provinces (municipalities) except Xinjiang, Tibet, Hong Kong, Macao, and Taiwan. However, billing cycles vary substantially across provinces, with some adopting an annual billing cycle and others adopting a monthly billing cycle. Notably, Guizhou, Hubei, Guangxi, and Chongqing switched their billing cycles from monthly to annual in January 2014, January 2015, July 2015, and January 2016, respectively. This setting creates a multi-period treatment-control structure, making it suitable for a multi-period difference-in-differences (DID) framework. Recent econometric literature has highlighted potential biases in two-way fixed effects (TWFE) estimators under staggered treatment adoption when treatment effects are heterogeneous across cohorts or over time. In this study, the timing of IBT implementation across provinces follows administrative rollout schedules rather than endogenous selection. Moreover, we supplement the TWFE specification with event-study analyses to examine dynamic treatment effects and pre-trends, which show no evidence of pre-trend violations and consistent post-treatment effects across cohorts. This helps alleviate concerns regarding potential bias in the TWFE estimator. The baseline regression model is specified as follows:

$$electricity_{ipt} = \alpha_0 + \alpha_1 DID_{pt} + \alpha_2 X_{ipt} + \lambda_i + \mu_t + \varepsilon_{ipt} \quad (16)$$

In the model, subscripts i, p, t denote household, province, and year, respectively. The dependent variable $electricity_{ipt}$ represents the annual electricity consumption of household i in province p at time t . The key explanatory variable, $treat_{pt}$, is a dummy variable indicating the billing cycle adopted in province p at time t . $treat_{pt}$ is equal to 1 if the province adopts an annual IBT scheme in year t and subsequent years; otherwise, it equals 0, indicating a monthly billing scheme. X_{ipt} denotes a set of household-level control variables used to capture household characteristics. λ_i represents household fixed effects, μ_t represents year fixed effects, and ε denotes the error term. α_1 and β_1 are the key coefficients of interest, capturing the effect of switching from monthly to annual billing on electricity consumption. A positive coefficient indicates that annual billing significantly increases household electricity consumption relative to monthly billing.

6. Regression Results

6.1. Baseline Regression

Table 4 reports the baseline regression results of Equation (16), examining the effect of switching from monthly to annual billing on household electricity consumption. Column (1) presents the results without control variables. Columns (2) and (3) report the results with household fixed effects and year fixed effects, respectively. Column (4) further includes both control variables, household fixed effects, and year fixed effects. The coefficients on the core explanatory variable remain positive and statistically significant across specifications. Using Column (4) as the benchmark specification, the estimated coefficient of electricity is 0.1310, which is significant at the 1% level. This suggests that households subject to an annual billing cycle consume, on average, 13.10% more electricity than those under a monthly billing cycle. These findings indicate that extending the billing cycle from monthly to annual leads to an increase in household electricity consumption, suggesting higher electricity consumption. This result is consistent with the theoretical predictions derived in this study and runs counter to the original policy objective of IBT, which is to promote electricity conservation.

Table 4. Baseline Regression Results of Electricity Consumption Effects.

Variable	(1)	(2)	(3)	(4)
<i>DID</i>	0.1366 *** (0.024)	0.1455 *** (0.020)	0.1163 *** (0.024)	0.1310 *** (0.024)
Natural Logarithm of Per Capita GDP		0.4448 *** (0.028)	0.8537 *** (0.023)	0.0824 (0.072)
Urban/Rural Attribute		0.3641 *** (0.016)	0.0898 *** (0.029)	0.0942 *** (0.028)
Natural Logarithm of Household Income		0.1794 *** (0.007)	0.0647 *** (0.007)	0.0430 *** (0.007)
Household Size		0.0866 *** (0.004)	0.0705 *** (0.006)	0.0769 *** (0.006)
Whether electricity is used as cooking fuel		0.1651 *** (0.015)	0.1091 *** (0.017)	0.1106 *** (0.016)
Household Fixed Effects	Yes	No	Yes	Yes
Year Fixed Effects	Yes	Yes	No	Yes
Constant Term	7.4729 *** (0.004)	4.2879 *** (0.080)	5.0902 *** (0.072)	6.5033 *** (0.128)
Observations	16,640	16,640	16,640	16,640
Adjusted R^2	0.608	0.354	0.595	0.622

Note: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are reported in parentheses.

6.2. Parallel Trend Test

A key assumption for the validity of the difference-in-differences (DID) model is that the treatment and control groups satisfy the parallel trends assumption. In this paper, we test the parallel trends assumption using relative treatment timing, with the model specified as follows:

$$electricity_{ipt} = \alpha_0 + \sum_{t=-2}^3 \delta_t D_{pt} + \alpha_2 X_{ipt} + \lambda_i + \mu_t + \varepsilon_{ipt} \quad (17)$$

where D_{pt} denotes a set of relative-time dummy variables indicating the years before and after the transition from monthly to annual IBT. X_{ipt} represents household-level control variables used to capture household characteristics. λ_i denotes household fixed effects, μ_t denotes year fixed effects, and ε is the error term. The coefficient δ_t captures the difference in household electricity consumption between the treatment and control groups for each relative year t after (or before) the policy change. The year in which each province switches from monthly to annual billing is used as the base period. Figure 1 presents the dynamic effects over the event window, while Table 5 reports the estimates for selected relative years. The results show that the pre-treatment coefficients are statistically insignificant and close to zero, indicating no significant differences in electricity consumption trends between the treatment and control groups prior to policy implementation. This suggests that the parallel trends assumption required for the DID model is satisfied. After the policy change from monthly to annual implementation, the estimated coefficients become significantly positive, indicating that annual billing leads to a persistent increase in household electricity consumption. This pattern is consistent with the baseline regression results and strengthens the validity of the empirical identification strategy, providing further evidence for the causal interpretation of the baseline estimate reported in Section 6.1. Overall, this dynamic specification provides further evidence supporting the validity of the DID identification strategy under staggered adoption. Although staggered DID estimators may be subject to bias when treatment effects vary across cohorts, the heterogeneity-robust event-study results indicate that the estimated effects are unlikely to be driven by differential pre-treatment trends across treatment cohorts. However, due to data availability and the timing of policy implementation, the event-study design includes a relatively short pre-treatment window. Therefore, while the formal joint test of the pre-treatment coefficients fails to reject the null hypothesis of parallel trends, the limited number of pre-treatment periods remains a limitation that should be considered when interpreting the results.

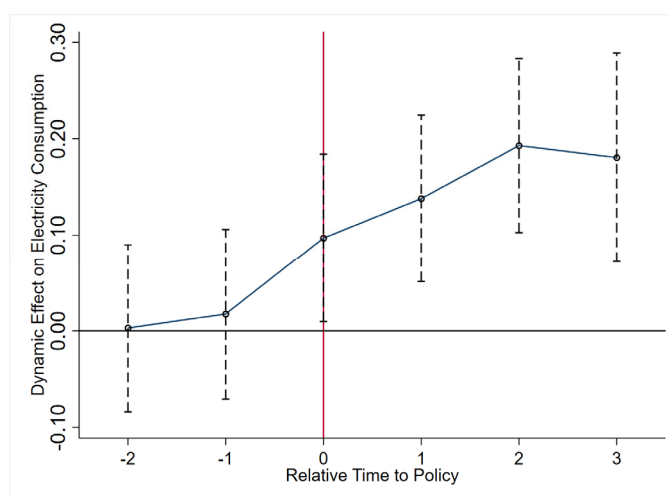


Figure 1. Parallel Trend Test of Electricity Consumption Effects.

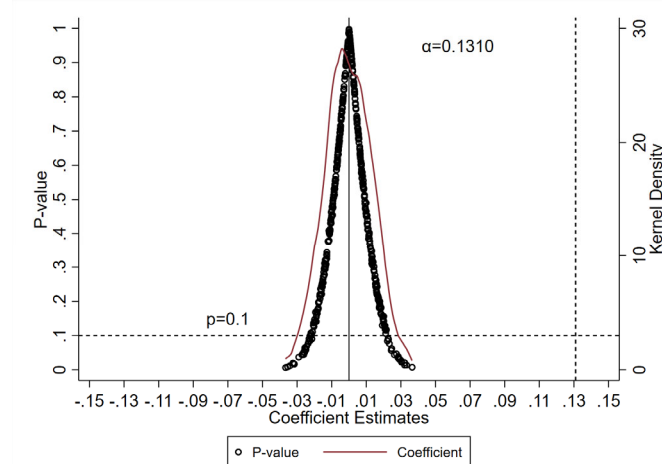
Table 5. Selected Event-study Estimates of Dynamic Treatment Effects.

Variable	Coefficient	Std. Error	z-Value	p-Value	95% Confidence Interval
Tm2	0.0241	0.0385	0.63	0.532	[−0.0514, 0.0996]
Tp0	0.0662 **	0.0331	2	0.046	[0.0012, 0.1311]
Tp2	0.1810 ***	0.0398	4.54	0	[0.1030, 0.2591]
Tp4	0.1717 ***	0.0497	3.46	0.001	[0.0743, 0.2691]

Note: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are reported in the table.

6.3. Placebo Test

To rule out the influence of unobserved omitted variables on the baseline regression results, this study conducts a placebo test by randomly assigning treatment groups. Specifically, both the timing and provincial assignment of policy switching from monthly to annual IBT are randomly generated to construct a set of false treatment groups. The model specified in Equation (16) is then re-estimated using these placebo samples. This procedure is repeated 500 times, generating 500 placebo coefficient estimates. Figure 2 reports the probability density distribution of the estimated coefficients for electricity consumption. The placebo coefficients of the core explanatory variable are mainly concentrated around zero, while the benchmark estimated coefficient of 0.1310 lies outside the placebo distribution. This indicates that the baseline results are unlikely to be driven by other unobserved factors. In addition, the scatter plot of p -values shows that the values are concentrated around zero and are far from the true estimated effect. Most observations lie above the dashed line ($p = 0.1$), indicating statistical insignificance at the 10% level. Overall, these results further confirm that the estimated effects in this study are unlikely to be driven by unobservable confounding factors.

**Figure 2.** Placebo Test of Electricity Consumption Effects.

6.4. Robustness Tests

To further verify the robustness of the baseline results, this study conducts a series of robustness checks, including excluding the impact of extreme events such as the COVID-19 pandemic, excluding the effect of seasonal electricity tariff schemes, and performing a PSM-DID estimation.

6.4.1. Excluding the Impact of Extreme Events

Since the sample used in this study includes observations during the COVID-19 pandemic period, which may have a significant impact on the estimation results, we exclude the pandemic-period data and re-estimate the effect of changes in the implementation cycle of IBT on household electricity consumption. As shown in Column (1) of Table 6, after excluding the pandemic years, the estimated effect on household electricity consumption remains positive and statistically significant at the 1% level, with a coefficient of 0.1087. This indicates that, absent the pandemic effect, switching from monthly to annual billing increases household electricity consumption by 10.87%, which is lower than the baseline estimate of 0.1310. This suggests that household electricity consumption increased during the pandemic due to home isolation or remote work, which is consistent with observed conditions during the pandemic. Overall, this result further validates that extending the billing cycle from monthly to annual significantly promotes household electricity consumption.

Table 6. Robustness Checks of Electricity Consumption Effects.

Variable	(1) Excluding the Impact of COVID-19 Years	(2) Excluding the Impact of Seasonal Electricity Tariffs	(3) PSM-DID Test
<i>DID</i>	0.1087 *** (0.025)	0.1476 *** (0.028)	0.1309 *** (0.024)
Natural Logarithm of Per Capita GDP	0.0966 (0.090)	0.4112 *** (0.143)	0.0844 (0.072)
Urban/Rural Attribute	0.0967 *** (0.030)	0.0855 ** (0.039)	0.0938 *** (0.028)
Natural Logarithm of Household Income	0.0422 *** (0.007)	0.0274 *** (0.009)	0.0423 *** (0.007)
Household Size	0.0694 *** (0.007)	0.0749 *** (0.008)	0.0772 *** (0.006)
Whether Electricity is Used as Cooking Fuel	0.1023 *** (0.018)	0.1686 *** (0.022)	0.1104 *** (0.016)
Household Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Constant Term	6.4663 *** (0.150)	6.0400 *** (0.221)	6.5076 *** (0.129)
Samples	13,915	10,546	16,640
Adjusted R^2	0.628	0.615	0.622

Note: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are reported in parentheses.

6.4.2. Excluding the Effect of Seasonal IBT Schemes

During the monthly implementation period, some provinces adopted seasonal IBT schemes, in which the tariff levels remained unchanged while the tier thresholds varied across seasons. For example, Guangdong Province divides its tariff thresholds into summer and non-summer standards, with lower thresholds in non-summer periods. Hunan Province distinguishes between spring–autumn and winter–summer periods, where the first-tier threshold remains the same, while the second- and third-tier thresholds in winter–summer are 100 kWh/month higher than in spring–autumn. Hainan Province differentiates between summer and winter standards, with higher thresholds in summer. To eliminate the influence of such seasonal tariff schemes, these provinces are excluded from the sample. As shown in Column (2) of Table 6, the estimated effect remains positive and statistically significant at the 1% level, with a coefficient of 0.1476. This implies that, after

excluding seasonal tariff effects, switching from monthly to annual billing increases household electricity consumption by 14.76%, further confirming the promoting effect of the policy change on electricity consumption. Moreover, the coefficient after excluding seasonal tariff schemes is larger than the baseline estimate of 0.1310, suggesting that the combined design of “combined IBT and seasonal tariff schemes” is more conducive to electricity conservation than a simple switch from monthly to annual implementation.

6.4.3. PSM-DID-Based Policy Evaluation

Figure 3 presents the balance test results of the propensity score matching procedure, while Table 7 reports the propensity score matching results based on a 1:5 nearest-neighbor matching strategy. An absolute standardized bias below 20% indicates satisfactory matching performance [38]. After matching, the standardized biases of all covariates between the treatment and control groups are significantly reduced. Specifically, the standardized bias decreases by 77.10% for the logarithm of per capita GDP, 99.10% for the urban–rural indicator, 95.70% for the logarithm of household income, 73.50% for household size, and 92.10% for whether cooking fuel is electricity. The absolute standardized biases after matching are all well below 20%, indicating that the two groups exhibit highly similar covariate characteristics after propensity score matching and that the balance test is satisfied. In addition, the pre-treatment control group becomes more comparable to the treatment group after matching, which helps reduce potential estimation bias in the DID analysis of policy effects.

Table 7. Propensity Score Matching Results.

Variable	Sample	Mean		Standard Error	Reduction in Standard Error	<i>p</i> -Value
		Treatment Group	Control Group			
Natural Logarithm of Per Capita GDP	Before Matching	1.5696	1.5741	−1.1%	0.7710	0.6290
	After Matching	1.5696	1.5706	−0.3%		0.9270
Urban/Rural Attribute	Before Matching	0.4713	0.5239	−10.5%	0.9910	0.0000
	After Matching	0.4713	0.4718	−0.1%		0.9730
Natural Logarithm of Household Income	Before Matching	10.8780	10.6050	23.6%	0.9570	0.0000
	After Matching	10.8780	10.8900	−1.0%		0.6970
Household Size	Before Matching	3.9306	3.9712	−2.3%	0.7350	0.2810
	After Matching	3.9306	3.9413	−0.6%		0.8250
Whether electricity is used as cooking fuel	Before Matching	0.3300	0.2483	18.1%	0.9210	0.0000
	After Matching	0.3300	0.3236	1.4%		0.6270

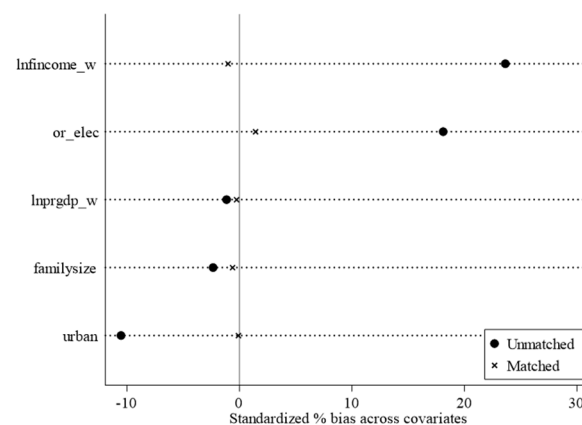


Figure 3. Balance Test Results.

Based on propensity score matching (PSM), this section re-estimates the baseline model, i.e., conducts a PSM-DID robustness test. The results reported in Column (3) of Table 6 show that the coefficient of the core explanatory variable is significant at the 1% level, with an estimated value of 0.1309. This indicates that, after the shift from monthly to annual implementation of IBT, household electricity consumption increases by 13.09%, which is almost identical to the baseline estimate of 0.1310. These findings suggest that the positive effect of changing the implementation cycle from monthly to annual on household electricity consumption remains statistically significant and robust across different sample selection strategies.

6.5. Heterogeneity Analysis

This study further examines the heterogeneous effects of changes in the implementation cycle of IBT on household electricity consumption from two perspectives: household income level and awareness of IBT policies. First, household per capita disposable income is used to distinguish between high- and low-income households. Households with per capita income above the annual urban–rural per capita disposable income reported in the China Statistical Yearbook from 2011 to 2021 are defined as high-income households, while those below this threshold are defined as low-income households. The results in Columns (1) and (2) of Table 8 show that the estimated coefficient of the core explanatory variable in Column (1) is significantly positive, whereas the coefficient in Column (2) is smaller and statistically insignificant. This indicates that the shift from monthly to annual billing has a more pronounced effect in promoting electricity consumption among low-income households. A possible explanation is that electricity expenditure accounts for a relatively small share of total consumption for high-income households, and their price elasticity of electricity demand is lower than that of low-income households. The price elasticity of electricity demand is -0.38 for low-income households and -0.08 for high-income households [26]. This difference implies that changes in electricity prices have a limited impact on high-income households, whereas low-income households are more sensitive to price changes; therefore, the policy effect is weaker for high-income groups.

Second, the educational attainment of the household head is used as a proxy for awareness of IBT policies. Households whose head has an education level of junior high school or below are defined as low-awareness households, while those whose head has a high school education or above are defined as high-awareness households. The results in Columns (3) and (4) of Table 7 show that the estimated coefficient in Column (3) is significantly positive, while the coefficient in Column (4) is smaller and statistically insignificant. This suggests that the shift from monthly to annual billing has a more pronounced effect on increasing electricity consumption among households with low awareness of IBT policies. A possible explanation is that more educated household heads are better able to understand the logic of electricity price adjustments and tend to behave more rationally in response to policy changes, making them less sensitive to changes in tariff mechanisms.

Table 8. Heterogeneity Tests of Electricity Consumption Effects.

Variable	(1) Low-Income Households	(2) High-Income Households	(3) Low-Education Households	(4) High-Education Households
<i>DID</i>	0.1641 *** (0.028)	0.0203 (0.056)	0.2035 *** (0.034)	0.0473 (0.038)
Natural Logarithm of Per Capita GDP	0.1103 (0.090)	0.1636 (0.187)	0.1716 (0.126)	0.1112 (0.137)

Urban/Rural Attribute	0.0705 *	0.1421 **	0.0697 *	0.0654
	(0.039)	(0.066)	(0.042)	(0.047)
Natural Logarithm of Household Income	0.0407 ***	0.0888 ***	0.0339 ***	0.0845 ***
	(0.010)	(0.031)	(0.009)	(0.014)
Household Size	0.0750 ***	0.0575 ***	0.0783 ***	0.0929 ***
	(0.008)	(0.015)	(0.008)	(0.011)
Whether Electricity is Used as Cooking Fuel	0.1267 ***	0.0913 ***	0.1461 ***	0.0111
	(0.019)	(0.034)	(0.022)	(0.030)
Household Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Constant Term	6.4353 ***	6.5789 ***	6.2980 ***	6.6037 ***
	(0.1587)	(0.432)	(0.200)	(0.277)
Samples	11,303	5337	9836	6804
Adjusted R ²	0.639	0.630	0.611	0.604

Note: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are reported in parentheses.

6.6. Mechanism Test

Based on the empirical results, the shift from monthly to annual implementation of IBT is associated with an increase in household electricity consumption. One possible mechanism is that extending the billing cycle reduces the effective electricity price faced by households and creates expectations of lower electricity prices, which in turn leads to excessive electricity consumption. It should be noted that the effective electricity price is a mechanically constructed measure based on policy-defined tariff blocks and exogenous threshold rules, which reduces concerns that it is directly determined by household behavior. Therefore, the following results should be interpreted as suggestive rather than strictly causal evidence of the pricing channel. To test this mechanism, this study constructs a four-equation mediation effect model, specified as follows:

$$pricing_{ipt} = \alpha_0 + \alpha_1 DID_{pt} + \alpha_2 X_{ipt} + \lambda_i + \mu_t + \varepsilon_{ipt} \quad (18)$$

$$electricity_{ipt} = \alpha_0 + \alpha_1 pricing_{pt} + \alpha_2 X_{ipt} + \lambda_i + \mu_t + \varepsilon_{ipt} \quad (19)$$

$$electricity_{ipt} = \alpha_0 + \alpha_1 pricing_{pt} + \alpha_2 DID_{pt} + \alpha_3 X_{ipt} + \lambda_i + \mu_t + \varepsilon_{ipt} \quad (20)$$

As reported in Table 9, the coefficient of the DID variable in Column (1) is significantly positive, indicating that the shift from monthly to annual implementation of IBT increases household electricity consumption by approximately 13.10%. In Column (2), the DID coefficient is significantly negative, suggesting that the policy change reduces the effective electricity price faced by households by about 2.43%. At the same time, given that the impact of electricity price changes on consumption may exhibit a lagged effect, the current-period electricity price can be interpreted as the expected price influencing next-period consumption. Accordingly, this study employs a one-period lag of electricity consumption to estimate the price elasticity of demand. As shown in Column (3), the estimated coefficient is significantly negative, with a price elasticity of approximately −0.3694, which is consistent with previous findings [39–41].

Given that the tariff structure is determined by policy-defined tier thresholds, variation in effective electricity prices is partly driven by the institutional design of the IBT system rather than solely by household consumption behavior. In Column (4), the DID coefficient remains significantly positive, while the expected electricity price is significantly negative, suggesting that changes in expected electricity prices may serve as a potential channel linking the policy change and household electricity consumption. Specifically, the policy reduces effective electricity prices, leading households to form lower price

expectations, which in turn is associated with higher electricity consumption through lower perceived electricity costs. This is consistent with the interpretation that the policy outcome may contradict the original objective of mitigating cross-subsidies in electricity tariffs. These findings are consistent with the proposed mechanism; however, the mediation analysis should be interpreted as identifying an association rather than establishing a definitive causal channel.

Table 9. Mechanism Test of Electricity Consumption Effect.

Variable	(1) Electricity Consumption	(2) Electricity Price Level	(3) Electricity Consumption	(4) Electricity Consumption
<i>DID</i>	0.1310 *** (0.024)	−0.0243 *** (0.002)		0.0517 * (0.030)
Electricity Price Level			−0.3694 *** (0.115)	−0.3448 *** (0.116)
Natural Logarithm of Per Capita GDP	0.0824 (0.072)	0.2257 *** (0.008)	0.3027 *** (0.095)	0.2748 *** (0.095)
Urban/Rural Attribute	0.0942 *** (0.028)	0.0156 *** (0.003)	0.0937 *** (0.034)	0.0978 *** (0.034)
Natural Logarithm of Household Income	0.0430 *** (0.007)	0.0024 *** (0.001)	0.0039 (0.008)	0.0041 (0.008)
Household Size	0.0769 *** (0.006)	0.0075 *** (0.001)	0.0237 *** (0.007)	0.0234 *** (0.007)
Whether Electricity is Used as Cooking Fuel	0.1106 *** (0.016)	0.0006 (0.002)	0.0406 ** (0.019)	0.0408 ** (0.019)
Household Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Constant Term	6.5033 *** (0.128)	−1.0061 *** (0.014)	6.3593 *** (0.191)	6.4055 *** (0.191)
Samples	16,640	16,640	12,380	12,380
Adjusted R^2	0.622	0.782	0.670	0.670

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in parentheses.

In addition, the mechanism can be further understood from the perspective of tariff-block exposure. Under the monthly billing scheme, electricity consumption is settled within shorter cycles, which may increase the likelihood that temporary consumption spikes during peak periods lead to higher tariff blocks. In contrast, annual billing aggregates consumption over a longer horizon, potentially smoothing short-term fluctuations and reducing the probability of entering higher tariff tiers. This may lower households' perceived marginal electricity costs and weaken consumption constraints, thereby increasing electricity demand. This interpretation is consistent with the decline in effective electricity prices observed after the transition to annual billing (Table 8).

However, the CFPS dataset only provides annual household electricity consumption and does not contain monthly billing records or detailed consumption profiles. Therefore, household exposure to specific tariff blocks cannot be directly identified, and the distribution of observations across tariff tiers before and after the transition cannot be accurately estimated. Accordingly, the tariff-block exposure mechanism should be interpreted as an institutional explanation that complements the observed effective price changes rather than as an independently identified causal pathway. Future research incorporating

monthly billing data, smart-meter records, or simulated tariff schedules could further examine this mechanism.

7. Conclusions and Policy Recommendations

This study uses CFPS data to investigate China's IBT policy and household electricity consumption. Based on a theoretical model, a multi-period difference-in-differences (DID) approach is employed to examine the impact of changing the billing cycle from monthly to annual settlement on household electricity consumption. Robustness checks are conducted to verify the empirical results. Heterogeneous effects across different income levels and degrees of policy awareness are analyzed, and the mechanism through which billing-cycle changes affect electricity consumption is examined.

7.1. Conclusions

The results show that shifting from monthly to annual billing significantly increases household electricity consumption. The multi-period DID results remain robust after controlling for household and time fixed effects, household characteristics, and regional differences, suggesting that annual billing does not merely change the settlement method, but also alters how IBT constrains household electricity consumption. Annual billing smooths monthly fluctuations in electricity consumption, reducing the likelihood of crossing higher tariff tiers. This in turn lowers the average effective electricity price faced by households and stimulates electricity usage. By shifting tier assessment from a monthly to an annual basis, annual billing reduces households' sensitivity to short-term marginal price fluctuations. As average electricity prices decline, households perceive electricity costs as more manageable, leading to less constrained consumption behavior and ultimately increasing residential electricity demand, while also increasing cross-subsidization within the tariff structure. The policy effects also differ across household groups: they are most pronounced among low-income and low-education households, who are more sensitive to price signals and more responsive to changes in marginal electricity costs. For these households, the lower frequency of pricing constraints under annual billing leads to a greater relaxation of consumption behavior and a more substantial increase in electricity usage, whereas high-income and high-education households exhibit minimal responses. These results suggest that the effects of annual billing differ substantially across household groups and are characterized by heterogeneity in price sensitivity and behavioral responses. Taken together, these findings highlight that the design of billing cycles plays an important role in shaping household electricity consumption behavior under increasing-block tariff systems. From a policy perspective, this implies that adjustments in billing frequency should be carefully evaluated in terms of their unintended effects on both consumption incentives and tariff equity. At the same time, it should be noted that the policy implication regarding a hybrid monthly–seasonal billing design is not directly tested in this empirical study, which focuses on the comparison between monthly and annual IBT schemes. Therefore, this suggestion should be interpreted as a conceptual extension rather than an empirically validated result. Future research could further evaluate the effectiveness of hybrid tariff structures using more granular policy and consumption data, while also investigating the institutional and policy factors underlying provincial transitions between monthly and annual billing schemes and their implications for causal identification.

7.2. Policy Recommendations

The policy implications derived from the identified effect that changes in the implementation cycle of China's IBT significantly promote household electricity consumption are as follows:

7.2.1. Optimization Focus

Future reforms should avoid treating longer billing cycles as a primary policy direction. Instead, greater emphasis should be placed on institutional responsiveness to seasonal load variations. Rather than smoothing short-term fluctuations through annual billing, it is preferable to promote a hybrid design combining monthly settlement with seasonal tier adjustments. Such a structure would better align tariff tiers with seasonal differences in heating and cooling demand as well as peak-off-peak consumption patterns, thereby maintaining affordability for households while preserving incentives for electricity conservation and the policy's role in encouraging energy conservation.

7.2.2. Signal Perceptibility

The perceptibility and comprehensibility of price signals should be incorporated as a key component of policy implementation. This can be achieved by improving electricity usage notifications and bill presentation formats to reduce delays in households' responses to price signals under longer billing cycles. In practice, policy design may strengthen real-time reminders around critical threshold points between tiers, changes in marginal costs, and feedback on consumption structure. This would reduce households' lag in perceiving price changes and avoid reinforcing the perception that electricity consumption is less costly under annual billing, thereby enhancing the behavioral constraint effect of IBT.

7.2.3. Targeted Support

Supporting policies should adopt a stratified and targeted governance approach, with more tailored energy-saving support and policy communication for low-income and low-education groups. Given that these households are more sensitive to price signals and more vulnerable to informational constraints, policymakers can provide clearer rule explanations, more accessible consumption alerts, and targeted energy-saving recommendations without increasing their financial burden. In addition, such measures can be coordinated with energy-efficient appliance subsidies and energy retrofitting programs, so as to improve the overall efficiency of the policy while mitigating distributional disparities arising from the reform.

Author Contributions: Conceptualization, Y.W. and Y.G.; methodology, Y.W.; software, Y.G.; validation, Y.W., H.Y. and Y.G.; formal analysis, H.Y.; investigation, Y.W.; resources, Y.G.; data curation, H.Y.; writing—original draft preparation, Y.W.; writing—review and editing, Y.G.; visualization, H.Y.; supervision, Y.W.; project administration, Y.G.; funding acquisition, Y.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Chinese Academy of Social Sciences, Youth Project (No. 22CJY064).

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Acknowledgments: We sincerely thank the reviewers for their valuable comments and the technical staff for their dedicated efforts and close cooperation during the field experiments.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Detailed Derivation of Optimal Monthly Electricity Consumption Under Monthly Billing Scheme

For each consumer type (heterogeneous demand), optimal consumptions under p_1 , p_2 and p_3 are q_t^1 , q_t^2 and q_t^3 , respectively, with $q_t^3 < q_t^2 < q_t^1$ by diminishing marginal

utility. Define q_{it}^1 , q_{it}^2 , q_{it}^3 as type i 's optimal consumption in month t under p_1 , p_2 , p_3 , respectively, and let $D(i)$ denote its demand function. In Figure A1, under p_1 , five representative types (with demand curves crossing tiers and critical points) have optimal levels q_{1t}^1 , q_{2t}^1 , q_{3t}^1 , q_{4t}^1 and q_{5t}^1 . In Figure A2, under p_2 , only types $D(3) \sim D(5)$ are considered; if their optimal consumption under p_2 falls below the first-tier threshold, it is billed at p_1 and thus excluded. Similarly for p_3 , only the relevant subset is considered. Hence the optimal levels under p_2 are q_{3t}^2 , q_{4t}^2 and q_{5t}^2 .

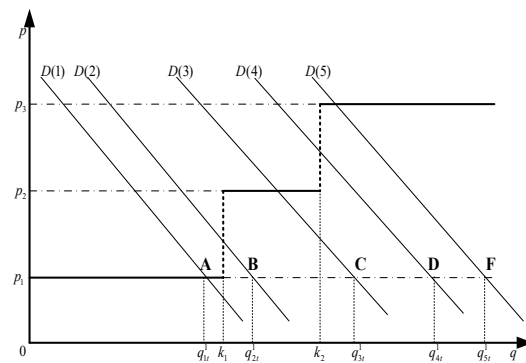


Figure A1. optimal electricity consumption under the first-tier IBT scheme.

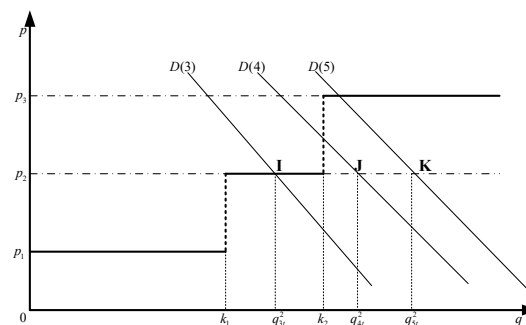


Figure A2. optimal electricity consumption under the second-tier IBT scheme.

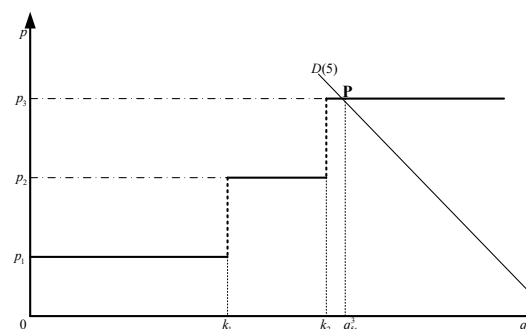


Figure A3. optimal electricity consumption under the third-tier IBT scheme.

From the analysis of Figures A1–A3, it is observed that the theoretically optimal consumption level may exceed the quota of the corresponding tariff tier. For example, points B , C , D , F in Figure A1, and points J , K in Figure A2, represent such cases. Although these points are theoretically optimal, under an IBT scheme with increasing marginal prices, the electricity price in the next tier is higher than that in the previous one, which may lead to a reduction in net utility. Consumer net utility must therefore be evaluated based on the tariff tier associated with the optimal consumption level. A complete discussion of this mechanism is provided below:

Appendix A.1. Discussion on the Position of the Optimal Consumption q_t^1

When $q_t^1 \leq k_1$, diminishing marginal utility gives $q_t^3 < q_t^2 < q_t^1 \leq k_1$; if actual consumption $q_t < q_t^1$, then $u'(q_t) > u'(q_t^1) = p_1$ and net utility is not maximized, while if $q_t > q_t^1$, then $u'(q_t) < u'(q_t^1) = p_1$ and net utility declines; hence the optimal actual consumption is $q_t^* = q_t^1$. Otherwise, when $q_t^1 > k_1$, the first-tier theoretical optimum exceeds the threshold, so the actual optimum must be determined by the second-tier theoretical optimum q_t^2 , which is discussed below.

Appendix A.2. Discussion on the Position of the Theoretical Optimal Electricity Consumption q_t^2 (Based on $q_t^1 > k_1$)

Since $q_t^3 < q_t^2 < q_t^1 \leq k_1$ always holds when $q_t^1 \leq k_1$ is satisfied, and the actual optimal consumption level is $q_t^* = q_t^1$, there is no need to separately discuss the position of q_t^2 . Instead, it is sufficient to consider the position of q_t^2 when $q_t^1 > k_1$ occurs, as detailed below.

1. When $q_t^2 \leq k_1$ is satisfied, it is equivalent to $q_t^3 < q_t^2 \leq k_1 < q_t^1$, and thus $p_1 < u'(k_1) < p_2$ always holds. As shown in Figure A4, if the user's actual electricity consumption is k_1 , the user's net utility is $V_1 = u(k_1) - p_1 k_1$, represented by area S_{IHFA} in the figure. When the user chooses an actual consumption level of q_t^2 (since choosing q_t^3 yields lower utility), and the tariff is based on the first-tier tariff, the net utility is given by area S_{IHCG} , implying $S_{IHCG} < S_{IHFA}$. Meanwhile, if the actual electricity consumption is q_t^1 , the corresponding net utility is $V_2 = u(q_t^1) - p_1 k_1 - p_2(q_t^1 - k_1)$, represented by area $S_{IHFA} + S_{ABF} - S_{ABDE}$, implying $S_{ABF} < S_{ABDE}$. Therefore, the difference in net utility, $V_2 - V_1 = u(q_t^1) - u(k_1) - p_2(q_t^1 - k_1) < 0$, always holds, and the optimal actual electricity consumption is k_1 .
2. As illustrated in Figure A5, when $k_1 < q_t^2 \leq k_2$ (the point E shown in the figure) holds, regardless of whether q_t^3 lies to the left or right of k_1 , since $q_t^3 < q_t^2$ always holds, the net utility from choosing q_t^2 is greater than that from choosing q_t^3 . Similarly, regardless of whether q_t^1 lies to the left or right of k_2 , since $q_t^1 > q_t^2$ always holds, choosing q_t^1 results in a net utility that is lower than the increase in electricity cost, thereby reducing net utility and making it smaller than that of choosing q_t^2 . Therefore, under all four configurations, the maximum net utility is achieved when actual electricity consumption equals q_t^2 , represented by area $S_{IHFA} + S_{DEF}$. Furthermore, comparing the net utility from choosing k_1 and q_t^2 , as shown in Figure A5, the net utility when choosing k_1 is represented by area S_{IHFA} , which is smaller than that of choosing q_t^2 (represented by area $S_{IHFA} + S_{DEF}$). Therefore, if $k_1 < q_t^2 \leq k_2$ applies, the optimal actual electricity consumption is q_t^2 .

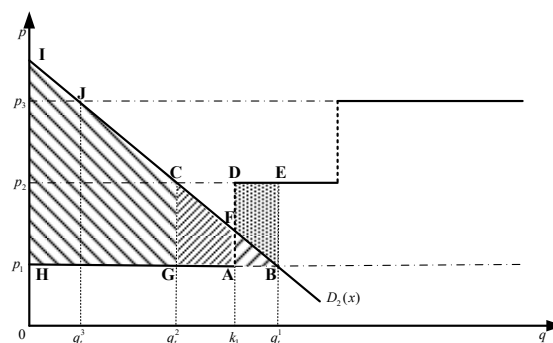


Figure A4. Comparison of the net utility of electricity consumption choices under condition $q_t^2 \leq k_1$.

$c_0 > p_j$ always holds, the cost gap is therefore positive. Hence, the annual cross-subsidization under monthly implementation is $S^{month} = \sum_{t=1}^T \sum_{j=1}^i (c_0 - p_i) \Delta q_{tj}$.

Appendix B.2. Cross-Subsidization Under Annual Implementation

In this case, the magnitude of cross-subsidization is given by:

$$S^* = c_0 Q^* - C(Q^*) \quad (A2)$$

The optimal annual electricity consumption Q^* , as specified in Equation (8), is assumed to fall within tier k (i.e., $k = 1, 2, 3$). The total annual electricity expenditure is $C(Q^*) = \sum_{j=1}^k p_i \Delta Q_j$, where ΔQ_j denotes the electricity consumption within tier j , the annual cost gap is $\sum_{j=1}^k (c_0 - p_i) \Delta Q_j$. Since $c_0 > p_j$ always holds, the cost gap remains positive. Hence, $S^* > 0$.

Appendix B.3. Comparison of the Relationship Between S^* and S^{month}

1. Since $Q^* \geq Q^{month}$ holds, it follows that $c_0(Q^* - Q^{month}) \geq 0$.
2. For the annual total electricity consumption under monthly implementation Q^{month} , if the same level of consumption is also chosen under annual implementation, i.e., $Q = Q^{month}$, then under the same electricity consumption level, the annual electricity expenditure is less than or equal to that under monthly implementation. Therefore, the electricity cost satisfies $C(Q^{month}) \leq \sum_{t=1}^T c(q_t^{month})$, and thus $S(Q^{month}) \geq S^{month}$ holds. Let $S(Q^{month})$ denote the subsidy amount under annual implementation at Q^{month} .
3. If $Q^* = Q^{month}$ holds, then due to $C(Q^{month}) \leq \sum_{t=1}^T c(q_t^{month})$, $S^* = c_0 Q^* - C(Q^*) \geq c_0 Q^{month} - \sum_{t=1}^T c(q_t^{month}) = S^{month}$ follows. If $Q^* > Q^{month}$ holds, then because of $c_0 > p_j$, the cross-subsidization associated with the additional electricity consumption is $\sum_{j=1}^k (c_0 - p_j) \Delta Q_j \geq 0$ (where ΔQ_j denotes the tier of the additional electricity consumption and j denotes the tier in which the additional electricity consumption falls). Therefore, we obtain $S^* = S(Q^{month}) + \sum_{j=1}^k (c_0 - p_j) \Delta Q_j \geq S(Q^{month}) \geq S^{month}$.

In summary, $S^* \geq S^{month}$ holds: the cross-subsidization under annual IBT implementation is greater than that under monthly implementation.

References

1. Ito, K. Do Consumers Respond to Marginal or Average Price? Evidence from Nonlinear Electricity Pricing. *Am. Econ. Rev.* **2014**, *104*, 537–563. <https://doi.org/10.1257/aer.104.2.537>.
2. Dutta, G.; Mitra, K. A Literature Review on Dynamic Pricing of Electricity. *J. Oper. Res. Soc.* **2017**, *68*, 1131–1145. <https://doi.org/10.1057/s41274-016-0149-4>.
3. Lin, B.; Zhu, P. Has Increasing Block Pricing Policy Been Perceived in China? Evidence from Residential Electricity Use. *Energy Econ.* **2021**, *94*, 105076. <https://doi.org/10.1016/j.eneco.2020.105076>.
4. Malik, A.; Urooj, A. Electricity Tariff Design. *Pak. Dev. Rev.* **2022**, *61*, 663–680. <https://doi.org/10.30541/v61i4pp.663-680>.
5. Zhang, H.J.; Tan, Z.F.; Xu, H. Research on Generation Coal-Saving Effect of the IBT of Residential Electricity under Different Power Generation Structures. *Appl. Mech. Mater.* **2013**, *415*, 697–701. <https://doi.org/10.4028/www.scientific.net/AMM.415.697>.
6. Sun, C.; Lin, B. Reforming Residential Electricity Tariff in China: Block Tariffs Pricing Approach. *Energy Policy* **2013**, *60*, 741–752. <https://doi.org/10.1016/j.enpol.2013.05.023>.
7. Zhang, X.; Tian, L. Implementation and Structural Design of IBT: An Empirical Analysis Based on Cross-Country Data. *Res. Financ. Econ. Issues* **2014**, *7*, 23–29. <https://doi.org/10.19654/j.cnki.cjwtyj.2014.07.004>.
8. Lee, S.; Hong, J.H. Effects of Relaxing South Korea's Increasing-block tariffs Structure on Residential Consumers. *Utilities Policy* **2025**, *97*, 102066. <https://doi.org/10.1016/j.jup.2025.102066>.
9. Borenstein, S. The Economics of Fixed Cost Recovery by Utilities. *Electr. J.* **2016**, *29*, 5–12. <https://doi.org/10.1016/j.tej.2016.07.013>.

10. Pacudan, R.; Hamdan, M. Electricity Tariff Reforms, Welfare Impacts, and Energy Poverty Implications. *Energy Policy* **2019**, *132*, 332–343. <https://doi.org/10.1016/j.enpol.2019.05.033>.
11. Zaki, D.A.; Hamdy, M. A Review of Electricity Tariffs and Enabling Solutions for Optimal Energy Management. *Energies* **2022**, *15*, 8527. <https://doi.org/10.3390/en15228527>.
12. Lin, B.; Jiang, Z. Designation and Influence of Household Increasing Block Electricity Tariffs in China. *Energy Policy* **2012**, *42*, 164–173. <https://doi.org/10.1016/j.enpol.2011.11.062>.
13. Liu, C.; Lin, B. Is Increasing-block tariffs Effectively Carried Out in China? A Case Study in Shanghai and Shenzhen. *Energy Policy* **2020**, *138*, 111278. <https://doi.org/10.1016/j.enpol.2020.111278>.
14. Liu, Z.; Yang, D.; Feng, Y. Evaluation and Optimization of Increasing-Block Pricing Policy: A Method Based on Sufficient Statistics. *Econ. Res. J.* **2017**, *52*, 181–194. <https://doi.org/10.19616/j.cnki.1002-2892.2017.03.009>.
15. Zhang, Z.; Li, E.; Zhang, G. How Efficient China's IBT Is for Household Electricity: Evidence from Survey Data. *Sustainability* **2023**, *15*, 893. <https://doi.org/10.3390/su15020893>.
16. Jia, J.J.; Guo, J.; Wei, C. Elasticities of Residential Electricity Demand in China under Increasing-Block Pricing Constraint: New Estimation Using Household Survey Data. *Energy Policy* **2021**, *156*, 112440. <https://doi.org/10.1016/j.enpol.2021.112440>.
17. Li, L.; Yuan, X.; Li, J.; Li, K. Assessing the Effect of Increasing Block Tariffs for Residential Natural Gas in Hefei City, China. *Util. Policy* **2024**, *90*, 101805. <https://doi.org/10.1016/j.jup.2024.101805>.
18. Wang, Y.; Lin, B. Performance of Alternative Electricity Prices on Residential Welfare in China. *Energy Policy* **2021**, *153*, 112233. <https://doi.org/10.1016/j.enpol.2021.112233>.
19. He, X.; Reiner, D. Electricity Demand and Basic Needs: Empirical Evidence from China's Households. *Energy Policy* **2016**, *90*, 212–221. <https://doi.org/10.1016/j.enpol.2015.12.033>.
20. Ma, Z.; Zhong, H.; Xia, Q.; Kang, C. A Block-of-Use Electricity Retail Pricing Approach Based on the Customer Load Profile. *IEEE Trans. Smart Grid* **2019**, *11*, 1500–1509. <https://doi.org/10.1109/TSG.2019.2895393>.
21. Liu, S.; Ye, W.; Wu, Y.; Ye, Z. An Improved IBT Scheme Considering Energy Saving and Carbon Reduction, Cross-Subsidy Handling, and User Demands. *Energies* **2025**, *18*, 2610. <https://doi.org/10.3390/en18102610>.
22. Li, L.; Yao, Y.; Yang, R.; Zhou, K. Is It More Effective to Bring Time-of-Use Pricing into Increasing Block Tariffs? Evidence from Evaluation of Residential Electricity Price Policy in Anhui Province. *J. Clean. Prod.* **2018**, *181*, 703–716. <https://doi.org/10.1016/j.jclepro.2018.01.209>.
23. Ansarin, M.; Ghiassi-Farrokhfal, Y.; Ketter, W.; Collins, J. A Review of Equity in Electricity Tariffs in the Renewable Energy Era. *Renew. Sustain. Energy Rev.* **2022**, *161*, 112333. <https://doi.org/10.1016/j.rser.2022.112333>.
24. Wang, X.; Wei, C.; Wang, Y. Does the Current IBT Structure Still Restrain Electricity Consumption in China's Residential Sector? *Energy Policy* **2022**, *165*, 112995. <https://doi.org/10.1016/j.enpol.2022.112995>.
25. Shah, I.; Akbar, S.; Saba, T.; Ali, S.; Rehman, A. Short-Term Forecasting for the Electricity Spot Prices with Extreme Values Treatment. *IEEE Access* **2021**, *9*, 105451–105462. <https://doi.org/10.1109/ACCESS.2021.3100076>.
26. Sun, C. Has the IBT Reform Achieved Both Efficiency and Equity Objectives? *J. Econ. Manag.* **2014**, *36*, 156–167. <https://doi.org/10.19616/j.cnki.bmj.2014.08.018>.
27. Ugwoke, B.; Sulemanu, S.; Corgnati, S.P.; Leone, P.; Pearce, J.M. Demonstration of the Integrated Rural Energy Planning Framework for Sustainable Energy Development in Low-Income Countries: Case Studies of Rural Communities in Nigeria. *Renew. Sustain. Energy Rev.* **2021**, *144*, 110983. <https://doi.org/10.1016/j.rser.2021.110983>.
28. Wang, M.; Yu, X. Impact of IBT Reform on China's Residential Electricity Use. *China Econ. Q. Int.* **2021**, *1*, 177–190. <https://doi.org/10.1016/j.ceqi.2021.08.001>.
29. Hu, S.; He, J.; Yang, C. Evaluating the Impacts of the Increasing Block Tariffs on Residential Electricity Consumption in China. *Sustain. Prod. Consum.* **2022**, *29*, 180–187. <https://doi.org/10.1016/j.spc.2021.10.008>.
30. Sun, C. An Empirical Case Study about the Reform of IBT for Household Electricity in China. *Appl. Energy* **2015**, *160*, 383–389. <https://doi.org/10.1016/j.apenergy.2015.09.030>.
31. Fang, Z.; Le, T.H.; Yu, J.; Fan, M. Evaluating Causal Effects of Increasing Block Pricing Policy on Residential Electricity Consumption in China. *Manag. Decis. Econ.* **2025**, *46*, 1661–1676. <https://doi.org/10.1002/mde.4124>.
32. Zhang, S.; Qin, X. *Lessons Learned from China's Residential IBT Reform*; International Institute for Sustainable Development: Winnipeg, MB, Canada, 2015.
33. Borenstein, S. The Redistributive Impact of Nonlinear Electricity Pricing. *Am. Econ. J. Econ. Policy* **2012**, *4*, 56–90. <https://doi.org/10.1257/pol.4.3.56>.

34. Cardenas, H.; Whittington, D. The Consequences of Increasing Block Tariffs on the Distribution of Residential Electricity Subsidies in Addis Ababa, Ethiopia. *Energy Policy* **2019**, *128*, 783–795. <https://doi.org/10.1016/j.enpol.2019.01.033>.
35. Lin, B.; Liu, X. Electricity Tariff Reform and Rebound Effect of Residential Electricity Consumption in China. *Energy* **2013**, *59*, 240–247. <https://doi.org/10.1016/j.energy.2013.07.021>.
36. Guizhou Provincial Development and Reform Commission. Notice on Further Improving the Residential Increasing-Block Electricity Pricing Policy in Guizhou Province. 2013. Available online: <https://fgw.guizhou.gov.cn/> (accessed on 9 July 2026).
37. Chongqing Municipal Price Bureau. Notice on Improving the Residential Increasing-Block Electricity Pricing System. 2015. Available online: <https://fzggw.cq.gov.cn/> (accessed on 9 July 2026).
38. Li, X.; Lu, Y. How Green Credit Policy Shapes Financial Performance: Evidence from Chinese Listed Construction Energy-Saving Enterprise. *Front. Environ. Sci.* **2022**, *10*, 1004247. <https://doi.org/10.3389/fenvs.2022.1004247>.
39. Lin, B.; Jiang, Z.; Lin, J. Targeted Tariff Subsidies Contribute to Energy Equity and Efficiency. *J. Financ. Res.* **2009**, *11*, 1–18.
40. Li, H.; Dong, L.; Xie, M. A Study on the Comprehensive Evaluation and Optimization of How Removing Gas and Electricity Subsidies Would Affect Households' Living. *Econ. Res. J.* **2011**, *46*, 100–112.
41. Liu, Z.; Deng, M.; Yang, D.; Ma, Y. Can Reducing Enterprises' Energy Costs Improve Energy Efficiency and Social Welfare?—An Analysis from the Perspective of Cross-Subsidies. *China Ind. Econ.* **2020**, *3*, 100–118. <https://doi.org/10.19581/j.cnki.ciejournal.2020.03.016>.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.