Cost, Tariffs, And Electricity Pricing In Iran: A Comparative Study

Sattar Mirzakuchaki[1], Navid Vaziri[2]*

[1]Professor, Department of Electrical Engineering, School of Electrical Engineering, Iran University of Science and Technology (IUST), Tehran, Iran
[2]Ph.D. Candidate, Department of Electrical Engineering, Iran University of Science and Technology (IUST), Tehran, Iran.
*Correspondence

ABSTRACT

In recent years, the design and implementation of electricity tariff mechanisms have become crucial for ensuring a sustainable supply, promoting consumption efficiency, and advancing social justice, serving as key tools in energy policy. In both developed and developing countries, industrial electricity prices are generally lower than residential prices to support production activities and maintain competitive commercial consumption. However, contrary to this global trend, the average ratio of industrial to residential electricity prices in Iran has increased in recent years, signaling a structural imbalance in the tariff system and support policies. Under the tiered pricing system, lower consumption levels are charged at cheaper rates, providing incentives for low-consuming groups. However, the segmentation of consumption and the determination of thresholds in Iran, particularly in tropical regions, require a thorough and equitable review. According to the 2020 tariff, in regular areas, the first tier (0–100 kWh), which offers the lowest rate, covers only about 25% of subscribers, while in Tropical Area 3, the first tier (0–1000 kWh) covers more than 93% of subscribers, resulting in a substantial subsidy for this group. This disproportionate subsidy has escalated to the point where, out of a total of 200 billion tomans in electricity subsidies during a hot month, more than 190 billion tomans (93%) is allocated to the first tier. Consequently, even with a significant increase in rates for higher tiers, it is impossible to fully eliminate subsidies for this region, and the financial imbalance in the electricity sector remains unresolved.

The objective of this comparative study is to examine the electricity tariff structures in Iran in relation to international standards, identify key challenges in defining consumption ranges and thresholds, and propose solutions to enhance economic efficiency, social justice, and transparency in the pricing process. The findings of this analysis could serve as a foundation for policymakers and regulatory bodies to reform the tariff tiers, adjust subsidies appropriately, and implement effective incentive rates, thereby ensuring both the financial sustainability of the grid and the promotion of optimized consumption and industrial production support.

Keywords: Tiered electricity tariffs, industrial-to-residential price ratio, consumption pattern thresholds, electricity subsidy, energy justice, energy pricing policy.

INTRODUCTION

Electricity tariffs, which determine how customers are billed for their energy consumption, play a crucial role in the economic sustainability of power systems and influence consumer behavior (Joskow & Wolfram, 2012). These tariffs, often structured as volumetric billing, price per kilowatt-hour, fixed capacity costs, or time-based rates, reflect the actual cost of electricity supply and can incentivize demand response and energy conservation (Branker et al., 2011; Jeon et al., 2025). A well-designed electricity tariff should strike a balance between cost recovery for distribution companies and consumer affordability, ensuring both grid investment and the maintenance of social justice (Zaki & Hamdy, 2022). However, the rapid integration of Distributed Energy Resources (DERs), such as rooftop solar panels and battery storage, has introduced new challenges for traditional one-way tariff models. These models now require reforms that account for bidirectional flows and variable generation (Ansarin et al., 2022). Additionally, advanced metering infrastructure and smart grid technologies have facilitated the implementation of dynamic pricing schemes—such as time-of-use rates and real-time rates—that reflect the real-time conditions of the system. However, these schemes also present challenges in terms of their complexity and accessibility for vulnerable groups (Khan et al., 2021).

Despite extensive studies on various tariff components and emerging pricing mechanisms, a comprehensive understanding of how different structures perform across diverse regulatory contexts and consumer groups is still lacking (Pérez-Santalla et al., 2022). Moreover, common metrics, such as the Levelized Cost of Electricity (LCOE), often fail to account for integration costs at the system level and the social justice implications (Branker et al., 2011; Chen et al., 2023).

Electricity prices play a vital role in shaping consumption patterns and guiding investment decisions. Research indicates that time-of-use tariffs can reduce peak demand by as much as 15%, thus enhancing grid reliability (Joskow & Wolfram, 2012). In contrast, flat volumetric rates can obscure the true cost of supply during peak hours, resulting in inefficient consumption (Borenstein & Bushnell, 2015). On the other hand, while fixed charges and capacity fees are essential for covering initial infrastructure costs, excessively high rates can distort price signals and reduce incentives for energy efficiency (Zaki & Hamdy, 2022).

Justice-oriented frameworks for tariff design propose integrated models that combine volumetric rates with targeted discounts or lifeline tariffs to support low-income households. However, empirical evidence at the regional level is still scarce, making it challenging to conduct precise assessments of the effectiveness of this approach (Khan et al., 2021; Sadat & Pearce, 2025).

While the Levelized Cost of Electricity (LCOE) is a standard metric for comparing generation technologies, it fails to account for grid integration costs, particularly the balancing requirements and additional storage needed for intermittent resources (Branker et al., 2011).

Moreover, international comparisons of electricity prices often use aggregated data from organizations like the International Energy Agency (IEA) and the World Bank, which may overlook significant domestic disparities between industrial, commercial, and residential sectors (Pérez-Santalla et al., 2022).

Regulatory reforms in various regions have introduced innovative tariff structures—such as peak-demand charges, dynamic critical-peak pricing, and seasonal block rates—to better align user costs with system requirements (Gunkel et al., 2022). However, designing tariffs that are both transparent and comprehensible for consumers remains a challenge, as excessive complexity can erode trust in the energy tariff system and reduce participation in demand response programs (Aurangzeb et al., 2021).

Concerns about data privacy and system compatibility also hinder the implementation of personalized pricing schemes based on smart meters (Khan et al., 2021). Ultimately, social justice considerations—ensuring that tariff changes do not disproportionately burden low-income or low-consumption households—necessitate comprehensive welfare analysis in addition to traditional cost-efficiency studies (Ansarin et al., 2022).

In several European countries, residential tariff structures are primarily based on energy consumption. However, some countries, including Sweden, Spain, and the Netherlands, have also integrated network capacity components (Nijhuis et al., 2017). This diversity in approaches reflects the understanding that electricity, due to the capital-intensive nature of the grid and its role as a basic necessity, is considered a public good (Nijhuis et al., 2017).

The strategic importance of energy distribution extends beyond the simple transmission of electricity; these systems are crucial for maintaining the balance of energy consumption and influencing broader economic processes. As such, tariff policies must account for the costs of network maintenance and business operations, while also anticipating social responses to price changes.

Based on these insights, this study is conducted with the following objectives:

- Classifying and comparing common electricity tariff structures and the fundamental principles of cost allocation;
- Evaluating tariff calculation methods;
- Assessing the social justice and welfare implications of different tariff regimes with varying levels of penetration;
- Identifying regulatory and enabling technological solutions, ranging from tariff reforms to advanced metering analyses, to improve economic efficiency and social justice in electricity pricing.

2. Electricity Tariffs and Pricing in Iran

The electricity sector in Iran experienced a significant transformation with the establishment of the wholesale electricity market in November 2003. This restructuring aimed to enhance price transparency, reduce costs, ensure an affordable energy supply, and attract private investment (Ostadi et al., 2018).

The market operates on a daily system, with competition primarily on the generation side, and financial agreements are made through the Pay-As-Bid (PAB) mechanism. Electricity generation companies submit their price proposals for each hour of the following day by 10:00 AM, and the Independent System Operator (ISO) of Iran evaluates these proposals to determine the Market Clearing Price (MCP) and production distribution schedules (Ostadi et al., 2018).

Governance Structure

The governance system of Iran's electricity sector is highly centralized, with the Ministry of Energy (MOE) serving as the primary legislative and policy-making authority (Eslamizadeh et al., 2020). The parent company, Tavanir (Iran's Electricity and Energy Company), a state-owned entity under the Ministry of Energy, is responsible for electricity generation, transmission capacity, and wholesale operations across the country. At the provincial level, regional electricity companies operate as subsidiaries of the Ministry of Energy, acting as the sole electricity service providers in their respective regions (Eslamizadeh et al., 2020).

Price Regulation and Consumer Participation

Despite efforts to liberalize the market, electricity pricing in Iran remains largely regulated, and the demand side does not actively engage in the auction process. Iran's electricity market employs a single-sided auction method to determine the clearing price. For end consumers, the annual electricity price is adjusted based on inflation rates and the average income increase (Niromandfam et al., 2020). The consumption pattern during different hours of the day plays a crucial role in determining the bill amount for industrial subscribers (Eslamizadeh et al., 2020).

Privatization and Strategic Challenges

Article 44 of the Constitution, which facilitated the transfer of power plants to the private sector, has heightened the importance of effective pricing strategies in Iran's electricity market (Kavoosi et al., 2021). However, historical pricing patterns suggest that suppliers often face challenges in developing optimal strategies during fuel supply constraints, with risk aversion leading to more conservative pricing approaches (Kavoosi et al., 2021).

Subsidies and Inefficiencies

One of the major challenges in Iran's electricity sector is the extensive use of subsidies. By 2018, Iran was the second-largest provider of direct subsidies to the electricity industry in the world, following China, and also provided substantial subsidies for fossil fuels, the primary fuel used by power plants. Despite privatization efforts since 2005, centralized economic management and these heavy subsidy programs have resulted in inefficiencies in electricity production and consumption. The absence of cost-based pricing has led to the exploitation of low-efficiency production units and artificially low electricity prices, contributing to wasted consumption (Mohammadipour, 2021).

Types of Electricity Tariffs in Iran

The Ministry of Energy has introduced two main types of electricity tariffs:

1. **Constant Electricity Pricing**
2. **Time-of-Use (TOU) Pricing**

For implementing TOU tariffs, smart meters are required that can register three different rates throughout the day, replacing old mechanical and analog devices. According to Iranian regulations, electricity prices during peak hours are four times higher than mid-peak prices, and during off-peak hours, the price is one-fourth of the mid-peak rate.

Consumer Category-Based Tariffs

- **Agricultural Sector**: Approximately $0.003 per kilowatt-hour (2015), the lowest rate among all sectors.
- **Industrial Sector**: Approximately $0.02 per kilowatt-hour.
- **Public Sector**: Approximately $0.06 per kilowatt-hour (Zarandi et al., 2018).
- **Residential Sector**: Uses an Increasing Block Tariff (IBT) structure with variable rates based on consumption levels and usage time (Hadizadeh et al., 2017).

Time-of-Use (TOU) Tariff Structure

- **Peak Hours**: Typically from 5:00 PM to 9:00 PM, with prices four times higher than mid-peak rates; equivalent to 1048 Rials per kilowatt-hour.
- **Mid-Peak Hours**: Usually from 7:00 AM to 5:00 PM and 9:00 PM to 11:00 PM, with a standard

rate of 524 Rials per kilowatt-hour (2019) (Hosseini et al., 2022; Rouhani et al., 2022).
- **Off-Peak Hours**: Usually from 11:00 PM to 7:00 AM, one-fourth of the mid-peak rate; equivalent to 262 Rials per kilowatt-hour (2019).

Residential Increasing Block Tariffs (IBT)

After targeted subsidy reforms, the residential tariff structure includes seven consumption blocks with increasing prices (Rouhani et al., 2022):
- **First Block**: 0–100 kWh per month
- **Second Block**: 100–200 kWh per month
- **Higher Blocks**: Gradual price increase for higher consumption levels.

Regional Pricing Variation
- **Tropical Regions (TRs)**: Lower prices in the hot months to account for increased demand for cooling.
- **Non-Tropical Regions (NTRs)**: Standard prices with two main six-month seasons and different peak periods (Sadat et al., 2020).

The current tariff structure is designed to support low-income consumers through block-based pricing, while also promoting energy savings, particularly during peak consumption periods (Rouhani et al., 2022). However, the significant differences in rates across consumer groups highlight the government's extensive subsidy policies, especially for the agricultural sector (Zarandi et al., 2018). The non-storable nature of electricity, coupled with its increasing consumption in Iran due to improved living standards, requires continuous investment in generation capacity to meet peak demand (Ojand et al., 2013).

Subsidies and Pricing Reforms in Iran

The electricity sector in Iran is characterized by significant government subsidies that have profoundly impacted production and consumption patterns. By 2018, Iran ranked second globally, after China, for providing direct subsidies to the electricity industry. In addition, extensive subsidies are also allocated to fossil fuels, which are the primary source of fuel for power plants (Mohammadipour, 2021).

These subsidies are distributed unevenly among consumer groups. For instance, in 2015, the Agricultural Sector received a subsidy of approximately $0.003 per kilowatt-hour, the lowest rate among all sectors. On the other hand, the Industrial Sector received about $0.02 per kilowatt-hour, and the Public Sector received approximately $0.06 per kilowatt-hour (Zarandi et al., 2018).

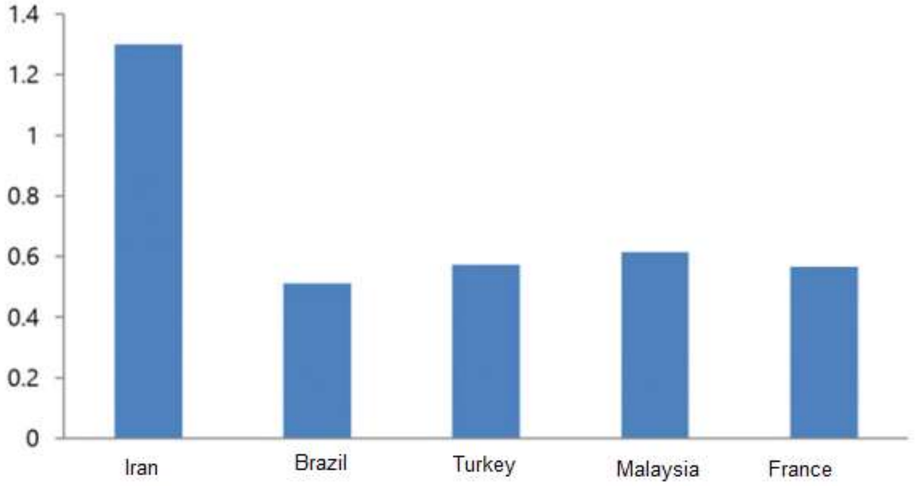

Figure 1: Comparison of the industrial-to-residential electricity price ratio in Iran and several countries worldwide (Rahimi et al., 2021).

As illustrated in the figure, in both advanced and developing countries, industrial electricity is typically cheaper than residential electricity. However, contrary to these countries, the average ratio of industrial to residential electricity prices in Iran has been high in recent years, deviating from the trend observed in the countries being compared.

The extensive subsidy policy has contributed to significant inefficiencies in Iran's electricity market. Despite privatization efforts since 2005, centralized economic management and both direct and indirect subsidy payments have continued to cause inefficiencies in production and consumption. The absence of cost-based pricing has resulted in the persistent use of low-efficiency production units, while artificially low electricity prices have fostered excessive consumption (Mohammadipour, 2021).

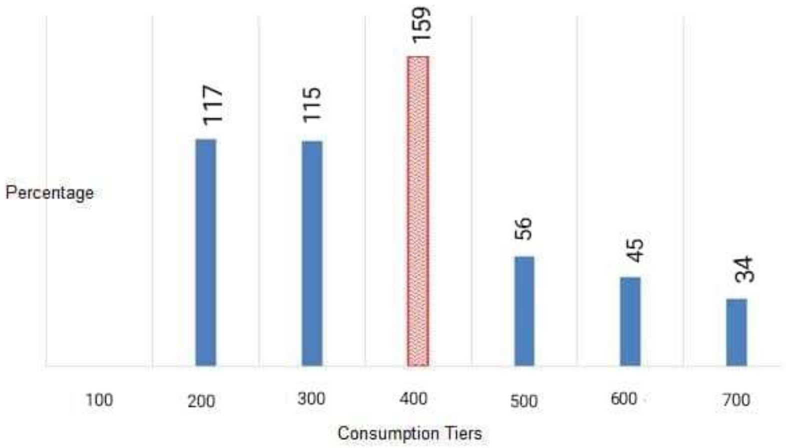

Figure 2: Percentage growth in the bill for each consumption tier compared to the previous tier (Rahimi et al., 2021).

In the tiered pricing system, lower tiers are more subsidized and offer cheaper electricity. Therefore, it is crucial to accurately and fairly determine the consumption ranges for these tiers. According to the 2020 tariff for standard regions, the first tier, which offers the lowest electricity prices, covers the range from 0 to 100 kWh, encompassing about 25% of subscribers in these areas. However, in tropical regions, the first tier extends from 0 to 1000 kWh, affecting about 93% of subscribers.

Interestingly, 1000 kWh represents the consumption threshold for this region, meaning that all subscribers consuming below this amount are placed in the same tier and are subject to the same electricity rate. As a result, during a hot month in the tropical region, more than 190 billion Toman (equivalent to 93% of the total 200 billion Toman subsidy) is allocated to the first tier. In such a case, even with substantial increases in the rates of higher tiers, it would be difficult to phase out the electricity subsidy in this region. This highlights a persistent imbalance in the electricity sector (Rahimi et al., 2021).

Response to these challenges: Pricing Reforms in Iran

In response to these challenges, the Iranian government has initiated a series of pricing reforms. One of the key actions taken by the Ministry of Energy (MOE) is the approval of a 7% annual increase in residential electricity prices. This move is part of a gradual strategy to reduce subsidies and improve the financial sustainability of the electricity sector. Such a pricing strategy has long-term implications for energy planning because, as electricity network prices rise over time, alternative energy sources, such as renewables, become increasingly cost-effective.

To support the development of renewable energy, Iran has introduced a guaranteed purchase system for electricity generated from renewable sources, although this system remains relatively new in comparison to other countries. Despite Iran's significant potential in renewable energy, factors such as inappropriate pricing mechanisms and the availability of relatively cheap oil and gas have slowed progress in this area (Qolipour et al., 2018). This situation underscores the influence of Iran’s subsidy policies not just within the electricity sector, but on broader energy transition goals.

A crucial aspect of electricity pricing policies is managing peak demand in the residential sector, which is influenced by factors such as electricity costs, tariff structures, consumption patterns, Gross Domestic Product (GDP), population growth, urbanization rates, technological development, and the number of residential subscribers (Neshat et al., 2018). The government’s reform efforts must navigate these variables while addressing the entrenched challenges posed by the extensive subsidy system.

As part of the ongoing subsidy reforms, the government plans to increase electricity tariffs for the agricultural sector in the second phase of the subsidy reform program. This increase will raise the cost of agricultural water, aiming to optimize water consumption and improve efficiency in this highly subsidized sector (Zarandi et al., 2018). These developments reflect a growing acknowledgment of the need for a shift toward more sustainable, cost-based pricing models in Iran.

3. Comparative Study of Electricity Tariffs in Other Countries

Factors Influencing Electricity Tariffs and Their Impact on Consumption

Electricity tariffs play a crucial role in the energy sector and significantly affect the dynamics of supply and demand. The design and structure of these tariffs are shaped by economic factors, emerging technologies, policy frameworks, and socio-economic considerations. The following section explores the most important of these factors and their effects on electricity consumption, drawing on relevant research.

Economic Factors

Economic factors are central to determining electricity tariffs, encompassing everything from fluctuations in energy prices and the costs of production, transmission, and distribution, to the implementation of taxes and subsidies. In Germany, the growing share of renewable energy and the need for demand responsiveness have contributed to the rise of real-time electricity tariffs, which aim to better align consumption with market conditions (Häseler & Wulf, 2024). Across the European Union, electricity pricing structures differ significantly among countries due to variations in energy market organization, tax policies, and network configurations (Matuszewska-Janica et al., 2023).

Economic Viability of Dynamic Tariffs

The economic viability of dynamic tariffs has also been studied in the context of rising energy prices. In Germany, it has been shown that with higher electricity prices and wider price spreads, these tariffs provide greater financial benefits for households with electric vehicles and battery storage systems, helping to offset the initial investment in home energy management systems (Stute et al., 2024).

Impact in Developing Contexts

In Ethiopia, the increase in electricity tariffs led to reduced consumption, but this effect is accompanied by infrastructure issues such as unreliable supply and frequent power outages, highlighting the interaction between economic and infrastructure factors (Tesfamichael et al., 2021).

Technological Advancements and Tariff Design

Technological advancements, especially the installation of smart meters and home energy management systems, have enabled the implementation of dynamic and real-time tariffs. These technologies provide more flexibility in electricity consumption and allow households to respond to price signals and adjust their consumption patterns. For example, in Germany, the use of HEMS and smart meters has been shown to improve the cost-effectiveness of dynamic tariffs, particularly for households using electric vehicles and heat pumps (Stute et al., 2024).

The integration of smart lighting solutions is another important technological advancement that impacts tariff design. In Turkey, it has been found that the use of low-lighting techniques and smart lighting control strategies reduces energy consumption, and the extent of this reduction varies depending on the tariff structure, such as fixed-rate tariffs or time-of-use tariffs (Akpınar & Polat, 2024).

Policy and Regulatory Frameworks

Policy and regulatory frameworks play a decisive role in the design and implementation of electricity tariffs. In Germany, policymakers have encouraged stricter regulations on real-time tariffs, using market forces to guide consumer behavior and ensure supply security at the lowest social cost (Häseler & Wulf, 2024). Similarly, in Poland, the introduction of time-of-use tariffs has led to significant changes in electricity consumption patterns, reducing peak demand and optimizing system load (Andruszkiewicz et al., 2021).

The impact of policy changes on electricity consumption has also been observed in Saudi Arabia, where the implementation of new tariffs in 2018 resulted in a significant decrease in energy consumption, a trend that continued in subsequent years, demonstrating the effectiveness of policy interventions in encouraging savings (Nahiduzzaman et al., 2023).

Infrastructure and Grid Tariffs

The design of grid tariffs is another key factor influencing electricity consumption. Grid tariffs are designed to reflect the costs of maintaining and operating the distribution network, helping to improve cost recovery by promoting the optimal use of network capacity. In Finland, the implementation of peak power-based tariffs has reduced distribution costs during periods of high electricity market prices, providing a more stable foundation for cost recovery (Haapaniemi et al., 2025).

The design of grid tariffs has also been examined in the context of electrification and socio-economic impacts. In Denmark, the introduction of time-dependent grid tariffs has reduced costs for low-income groups and smaller households while promoting the use of flexible technologies such as electric vehicles and heat pumps (Gunkel et al., 2023; Gunkel et al., 2022).

Socio-Economic Factors and Equity Considerations

Socio-economic factors, including income levels and household characteristics, play an important role in shaping the impact of electricity tariffs on consumption. In the United States, the effectiveness of dynamic pricing programs in reducing energy poverty has been studied, and it has been shown that time-of-use tariffs and critical peak pricing can reduce the energy burden on low-income households (Pereira & Marques, 2023).

In Norway, the response to critical peak pricing has been widespread, and similar reductions in electricity consumption have been observed among different income groups, indicating that well-designed pricing policies can have equity-oriented effects even in highly electrified societies (Garnache et al., 2022).

Environmental and Behavioral Factors

Environmental factors, such as temperature, also influence electricity consumption patterns and, consequently, tariff design. In China, the consumption response curve to temperature has shown that implementing time-of-use pricing policies can control electricity consumption by adjusting demand during peak temperature periods (Li et al., 2022).

Behavioral factors, including energy awareness and willingness to adjust to price signals, are also critical in determining the effectiveness of tariffs. In Saudi Arabia, the application of revised tariffs has strengthened energy-saving behaviors, with factors such as the type of residence and the number of occupants influencing the level of consumption reduction (Nahiduzzaman et al., 2023).

Tariff Design and Its Impact on Electricity Consumption

The structure of electricity tariffs has a direct influence on consumption patterns. Time-of-use tariffs, which adjust prices based on the time of day, have been effective in lowering peak demand and shifting usage to off-peak periods. In Poland, the introduction of such tariffs has significantly impacted system load, and incentives targeted at large residential users have led to a notable decrease in peak demand (Andruszkiewicz et al., 2021). The effects of tariff design on electricity consumption have also been examined within the framework of dynamic pricing programs. In the United States, time-of-use and critical peak pricing tariffs have helped reduce the number of households experiencing energy poverty. However, real-time pricing has been associated with an increase in energy poverty, emphasizing the importance of careful and balanced program design (Pereira & Marques, 2023).

Table 1: Comparison of Types of Tariffs and Their Impacts

Tariff type	Impact on electricity consumption	**References**
Real-Time Tariffs	Encouraging demand response and reducing energy costs by aligning consumption with market conditions	(Häseler & Wulf, 2024)
Time-of-Use Tariffs	Reducing peak demand and shifting consumption to off-peak hours	(Andruszkiewicz et al., 2021)
Dynamic Tariffs	Reducing energy poverty in low-income households	(Pereira & Marques, 2023)
Grid Tariffs	Promoting optimal use of network capacity and reducing network costs	(Ma, 2011; Zaki & Hamdy, 2022)
Critical Peak Pricing	Reducing peak demand, but in some cases, it may lead to an increase in energy poverty	(Pereira & Marques, 2023)

Factors Influencing Electricity Tariffs and Their Impact on Consumption

The factors influencing electricity tariffs and their impact on consumption are complex and multifaceted. Economic conditions, technological advancements, policy frameworks, infrastructure, socio-economic factors, and environmental considerations all play a role in shaping tariff designs and consumption patterns. The effectiveness of different types of tariffs (including real-time, time-of-use, and dynamic tariffs) has been demonstrated in various contexts, showing their potential to reduce peak demand, promote energy efficiency, and alleviate energy poverty. However, careful attention to the socio-economic impacts and equity in tariff design is essential to ensure that the benefits of demand response are distributed fairly among all households.

Fundamental Principles of Electricity Tariff Design

Effective electricity tariff design requires balancing several fundamental principles: economic efficiency, equity, and transparency, which serve as criteria for comparing different tariff structures (Morell Dameto et al., 2020). The development of sustainable tariffs inevitably involves trade-offs among stakeholders with conflicting interests—consumers seeking lower rates, suppliers aiming for higher profits, and governments looking for a balance between economic access and reasonable returns for suppliers (Kyari et al., 2021).

Cost-Reflectivity is the cornerstone of tariff design, particularly in competitive markets. From an economic perspective, the tariff system must ensure full cost recovery and efficiency, which is a challenging task (Borquez et al., 2020). Some experts argue that fully cost-reflective tariffs can attract private investment and create competition, ultimately lowering electricity prices. However, in developing countries, the full implementation of cost-reflective tariffs may conflict with social goals and make electricity more expensive for vulnerable groups (Maphosa et al., 2017).

This inherent tension between regulatory and economic aspects leads to exchange-based approaches: marginal pricing promotes efficiency by sending appropriate price signals but often fails to fully recover network costs; in contrast, simple flat-rate structures guarantee full cost recovery but sacrifice economic efficiency by eliminating demand response (Borquez et al., 2020). The theoretical foundation of efficient pricing goes back to Boiteux's work on peak load pricing, which showed that prices should reflect the marginal operational costs of the system during off-peak periods and marginal long-term costs during peak periods (Steiner, 1957; Schittekatte et al., 2024).

In practice, countries adopt various methods such as marginal cost pricing, average cost pricing, two-part tariffs, and multi-year tariffs, depending on factors such as information access, market responsiveness, and competition dynamics (Kyari et al., 2021; Borenstein et al., 2015; Anosike et al., 2017). An increasing consensus among regulators and academics is emerging for a shift from primarily volumetric tariffs to capacity-based structures that better incorporate time and location factors (Savelli et al., 2020; Perez-Arriaga et al., 2017). This shift is particularly important for addressing equity concerns, as net-metered volumetric tariffs allow distributed generation holders to reduce their network costs without lowering the actual network costs, thereby transferring this burden to non-privileged households (Savelli et al., 2020; Schittekatte et al., 2018).

An emerging approach for network cost allocation is dividing total costs into incremental and residual components. Simultaneous peak charges are designed to reflect the actual network usage costs and encourage behaviors that reduce future reinforcement needs, while residual charges recover the remaining costs without distorting the consumer's response to cost-reflective signals (Morell Dameto et al., 2020).

In many developing economies, Increasing Block Tariffs (IBT) are common, where lower consumption levels are charged at lower rates. While these structures are designed to support low-income households, they often result in tariffs that are below actual costs and impose a significant financial burden on governments (Coady, 2023). Managing these financial pressures while maintaining affordability for vulnerable groups remains one of the primary challenges in electricity tariff reform.

4. Types of Electricity Tariff Structures

Flat and Volumetric Tariffs

Flat rate tariffs are the simplest pricing structure where the consumer pays the same rate regardless of the time of consumption (Ma et al., 2021). These traditional volumetric tariffs generally operate based on the amount of energy consumed and are common in many European countries (Nijhuis et al., 2017). Their simplicity makes them understandable for consumers, but they do not reflect the variable costs of electricity supply throughout the day (Mohamed et al., 2017).

Two-Part Tariffs

Two-part tariffs were developed in response to the differing costs of supplying various loads (Ma et al., 2021). These tariffs typically include a fixed component (usually related to capacity or connection costs) and a variable component based on consumption (Eid et al., 2016). This concept is based on marginal cost principles, which, despite the evolution of implementation methods, remain fundamental in tariff design (Ma et al., 2021; Vickrey, 1948).

Time-of-Use – TOU Tariffs

Time-of-use (TOU) tariffs divide the day into different time periods with varying prices; typically, higher rates apply during peak hours, and lower rates apply during off-peak hours (De Filippo et al., 2017; Mohamed et al., 2017). These tariffs reflect the average cost of electricity generation and delivery during different periods and encourage consumers to shift consumption to off-peak hours (Taik et al., 2022). TOU tariffs are particularly popular in demand response programs due to their relatively simple structure, which allows consumers to interact with them easily (Taik et al., 2022). Studies have shown that TOU tariffs can be effective in shifting demand and reducing system peaks, but their effectiveness depends on the peak-to-off-peak price ratio, which is typically between 2 and 4 (Dong et al., 2017; Christensen et al., 2021).

Critical Peak Pricing – CPP

Critical peak pricing (CPP) applies much higher rates during specific hours announced by the network operator in periods of severe system stress (Willems et al., 2020). Unlike standard TOU tariffs, CPP provides stronger price signals during critical conditions (Andruszkiewicz et al., 2019; Wolak, 2011).

Real-Time Pricing – RTP

Real-time pricing (RTP) is the most dynamic tariff structure, where electricity prices change hourly or sub-hourly based on wholesale market conditions (D'Ettorre et al., 2022). RTP is the most discussed dynamic tariff in the literature and typically uses energy as the cost factor, although some implementations also consider power components (Christensen et al., 2021; Huang et al., 2019). Despite the theoretical benefits of efficiency, the adoption of dynamic pricing mechanisms has remained relatively low, although some European countries have made progress; for example, about 9% of customers in Finland use dynamic pricing based on real-time market prices, and in Norway, nearly 45% of residential customers have variable-rate contracts (D'Ettorre et al., 2022).

Increasing Block Tariffs – IBTs

Increasing block tariffs (IBTs) apply higher rates for consumption above certain thresholds. This structure is common in developing economies and aims to support low-income households with lower rates for lower consumption. For example, Vietnam uses IBTs for residential electricity pricing (Bui, 2021).

Capacity-Based Tariffs

Capacity-based tariffs consider costs based on the consumer's maximum power demand since network costs are largely a function of peak capacity needs rather than total energy consumption. Only a few European countries, such as Sweden, Spain, and the Netherlands, have included capacity components in residential tariffs, and Italy is also introducing such elements (Nijhuis et al., 2017).

5. Emerging Tariff Structures

Recent research has focused on more innovative tariff designs, including:

Prediction-of-Use Tariffs, where customers predict their future consumption and are billed based on actual consumption and deviations from the forecast (Khan et al., 2021; Robu et al., 2014).

Time-and-Level-of-Use Tariffs, which operate based on traditional time-of-use (TOU) tariffs and add a component for self-declared capacity reservation (Khan et al., 2021; Besancçon et al., 2018).

Dynamic Power Tariffs, designed for managing congestion in distribution networks with high penetration of electric vehicles and heat pumps (Huang et al., 2019).

Locational Marginal Pricing at the Distribution Level, which can provide more precise signals of network loading but faces practical implementation challenges (Willems et al., 2020).

These emerging structures aim to better align electricity pricing with the complex and dynamic costs of operating modern power systems—especially those with high penetration of distributed energy resources (DERs) (Pinel et al., 2019; Schittekatte et al., 2018).

Cost Components and Pricing Determination

Electricity tariff design fundamentally revolves around ensuring the recovery of the costs of providing electricity services. In this context, "costs" refer to the expenses that distribution companies or retailers incur to supply electricity, and "charges" are the amounts collected from consumers in exchange for their usage (Eid et al., 2016).

The cost-causality principle, where electricity prices accurately reflect the costs imposed on the system, forms the theoretical foundation of efficient and economic tariff design (Eid et al., 2016; Sotkiewicz et al., 2007).

The cost structure that forms the basis of tariffs varies depending on the market organization. In traditional vertically integrated companies—still common in many U.S. states—a single regulated tariff may cover a combination of network and supply costs. However, in liberalized markets where the network (monopoly) is separate from competitive sectors (generation and retail), tariff components are defined separately for each service (Eid et al., 2016).

One of the main challenges in tariff design is recovering the fixed network costs, which constitute a significant portion of the system's total costs. This issue is exacerbated by the emergence of prosumers and distributed generation, as they can reduce their network bills under volumetric tariffs without decreasing the overall network costs (Pinel et al., 2019; Schittekatte et al., 2018).

6. Country-Specific Tariff Models and Approaches

Electricity tariff design varies significantly across countries, influenced by the legal frameworks, market structures, and socio-economic priorities unique to each nation. In recent decades, many countries have transitioned from vertically integrated monopolies to deregulated, competitive environments (Girish et al., 2013). This shift has radically transformed the way electricity is priced, treating it as a commodity that can be bought, sold, and traded—despite its unique characteristics, such as immediate consumption and limited storage capacity (Girish et al., 2013).

Residential Tariff Structures in Europe

In European countries, the tariff structure for residential customers varies significantly. In most countries, residential tariffs are primarily based on energy consumption. However, in Sweden, Spain, and the Netherlands, capacity components are also included, and Italy is in the process of adding such elements (Nijhuis et al., 2017). This diversity reflects the widespread view of electricity as a public good, given the capital-intensive nature of the network and its status as a basic necessity (Nijhuis et al., 2017).

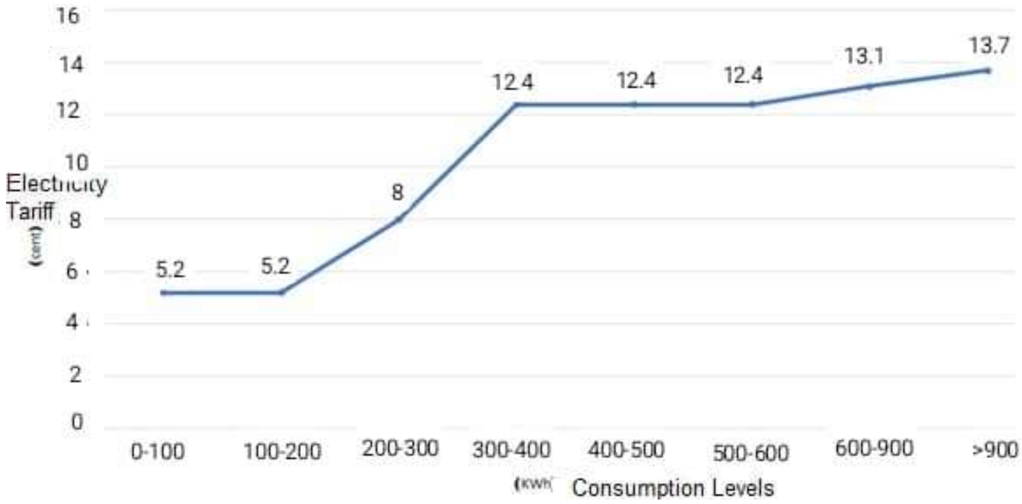

Figure 3: Residential Electricity Tariff in Malaysia (Rahimi et al., 2021)

Advances in Dynamic Pricing Mechanisms in Nordic Countries

Nordic countries have made significant progress in implementing dynamic pricing mechanisms. In Finland, nearly 9% of customers use dynamic pricing tariffs based on real-time market results from Nord Pool, with the electricity price for the following day being published daily on retail websites (D'Ettorre et al., 2022). Similarly, around 45% of Norwegian residential consumers have opted for variable price contracts, which combine a fixed tariff with the average monthly Nord Pool price (D'Ettorre et al., 2022). Sweden follows a similar approach, with most households preferring variable pricing options (D'Ettorre et al., 2022).

Tariff Outlook in Developing Economies

In developing countries, priorities often vary. For example, Vietnam classifies electricity users into four categories (residential, industrial, administrative, and commercial) and applies three types of tariffs: Increasing Block Tariffs (IBTs), Time-of-Use (TOU) tariffs, and voltage-level-based pricing (Bui, 2021). IBTs are the most common structure for residential consumers, offering lower rates for lower consumption levels to support vulnerable households (Coady, 2023). However, these structures often result in tariffs that are lower than the cost of supply, placing significant financial strain on government budgets (Coady, 2023).

Example of Conflict Between Cost-Reflective Pricing and Social Goals (South Africa)

South Africa exemplifies the conflict between cost-reflective pricing and social objectives. The ongoing debate centers on whether cost-reflective tariffs can attract private investment and reduce prices through competition, or if such tariffs make electricity unaffordable for the majority of the population. The fundamental question of whether the focus should be on cost-reflective tariffs or pro-poor tariffs remains unresolved in many developing countries (Maphosa et al., 2017).

Regulatory Impacts on Electricity Pricing

Studies have shown that regulatory reforms in electricity tariff structures have resulted in varying outcomes across different regions. Some studies report significant reductions in final consumer prices, while others document price increases (Bensch, 2019). Research on electricity companies in Latin America indicates that, under the oversight of regulatory bodies, residential tariffs increased by 14%, industrial tariffs decreased by 5%, and the cost recovery ratio improved by 13%. This suggests that the overall tariff structure and the ability to recover costs are key factors influencing the outcomes of regulatory reforms (Bensch, 2019).

Global Survey of Tariff Practices

A global survey conducted across more than 60 countries found that the average electricity tariff for 2015-2016 was approximately $0.13 per kilowatt-hour, but there were significant disparities, with the highest tariff being 40 times higher than the lowest. The study revealed that tariffs generally fail to recover capital costs and are not adjusted in line with inflation rates. Furthermore, tariff structures often fall short in addressing technological changes, such as the inappropriate application of fees linked to load for fixed network costs, the continued use of stepped tariff increases for residential consumers, and the underutilization of time-of-use tariffs (Foster et al., 2020).

Australia’s Experience with Demand-Based Tariffs

In Australia, demand-based tariffs were introduced to address pricing disparities and cross-subsidies between traditional consumers and prosumers—those who both produce and consume electricity (Azuatalam et al., 2018). Research has shown that these tariffs effectively reduce network price volatility and provide stable revenue for distribution network operators (Azuatalam et al., 2018; Young et al., 2016). However, their alignment with the cost-reflective principle largely depends on the assumptions made during the design process and how customers respond to these tariffs (Azuatalam et al., 2018).

Demand Response and Tariff Design

Recent research on demand response has revealed diverse effects of price signals on network usage and consumer flexibility. These studies also emphasize the potential risks and unintended consequences that tariffs may have on different consumer groups, especially those with varying socio-economic and technical characteristics—most notably, the challenges faced by vulnerable households. Household network tariff design generally follows two main approaches: one involves time-based unit price differentiation, which targets overall energy consumption and system peak periods; the other provides capacity-based signals that focus on individual peak usage (Gunkel et al., 2022).

Challenges and Transformation in Electricity Tariff Design

The rise of Distributed Energy Resources (DERs) and the growing number of prosumers—consumers who also produce electricity, such as through rooftop solar panels—pose significant challenges to traditional electricity tariff structures. Conventional volumetric tariffs combined with net metering often lead to cross-subsidization, where non-producing consumers subsidize prosumers (Pinel et al., 2019; Schittekatte et al., 2018). This pricing approach fails to reflect the actual cost structure faced by distribution operators, which typically involves high fixed costs and relatively low variable costs (Pinel et al., 2019). Research indicates that such tariff models can distort investment decisions by making batteries and solar installations appear more economically attractive than they actually are, while unfairly shifting costs to other consumers (Pinel et al., 2019; Schittekatte et al., 2018).

A central challenge in tariff design is the tension between regulatory simplicity and economic efficiency. Regulators aim to implement clear and understandable pricing structures that allow stakeholders to respond appropriately to price signals (Borquez et al., 2020). However, while marginal pricing is theoretically efficient, it often fails to recover the full cost of operating the grid. In contrast, simple flat-rate tariffs may ensure cost recovery but reduce economic efficiency by removing incentives for demand-side responsiveness. This fundamental conflict between clarity and competitiveness has made tariff design particularly complex.

In developing countries, the tension between cost-reflective pricing and social equity is even more pronounced. Ongoing debates persist between those who advocate for cost-reflective tariffs as a way to attract private investment and lower long-term prices through competition, and those who warn that such tariffs could make electricity unaffordable for low-income and vulnerable populations.

Equilibrium Models & Game Theory

Recent research has approached tariff design as an equilibrium problem between consumers and network operators, employing game theory to analyze their interactions (Askeland et al., 2019; Schittekatte et al., 2018; Vespermann et al., 2018). These models demonstrate how various tariff structures affect consumer behavior and overall system costs. However, they often face limitations in assessing multiple scenarios or identifying optimal time-dependent pricing structures (Askeland et al., 2019).

Consumer Responsiveness and Price Elasticity

The effectiveness of tariff reforms largely depends on consumer responsiveness to price signals, which is a complex parameter. Studies have shown that price elasticity estimates vary widely, ranging from -0.06 to -1.25 (Torriti, 2020). This broad range reflects methodological differences and local factors. Generally, electricity demand elasticity is relatively low, and evidence suggests that residential users do not typically delay energy-dependent activities to take advantage of off-peak tariffs (Torriti, 2020; Schatzki, 2010).

Broader Considerations in Tariff Design

In addition to influencing consumer behavior, tariff design must take into account broader energy system factors. Differentiated tariffs can be instrumental in enhancing energy efficiency among large industrial enterprises and in managing overall electricity consumption more effectively (Muratov et al., 2023). Energy distribution companies are not only tasked with transmitting electricity but also with balancing demand and contributing to wider economic dynamics. As such, tariff policies should carefully balance the costs of maintaining the network with the potential social and economic impacts of price changes.

Increasing Complexity in Tariff Design

A review of recent literature shows that various policies—including network tariffs, taxes, and subsidies—affect different actors in the energy system (Gunkel et al., 2023). As the penetration of distributed energy resources continues, integrating these policy tools to achieve both economic efficiency and social goals becomes increasingly important.

7. Future Directions and Emerging Trends

Influence of Distributed Energy Resources (DERs) and Prosumers

The rise of Distributed Energy Resources (DERs) and the emergence of prosumers are among the primary forces driving changes in tariff design. This shift significantly alters how electricity networks are used and necessitates a more accurate allocation of costs and benefits. Research highlights that poorly designed network tariffs can distort investment decisions, create inappropriate incentives for technologies such as batteries and solar panels, and unfairly shift costs onto consumers who do not directly benefit from these technologies (Pinel et al., 2019; Schittekatte et al., 2018).

Capacity Booking Consensus

There is growing agreement among regulators and researchers on the need to adopt capacity-based tariffs and to incorporate time and location considerations into network tariff structures (Savelli et al., 2020; Perez-Arriaga et al., 2017). This move away from traditional volume-based tariffs is especially important in the context of net-metering systems, which can over-incentivize distributed generation without necessarily leading to reductions in overall network costs (Savelli et al., 2020).

Digitization and the Future of Tariffs

The integration of digital technologies with innovative pricing strategies has heightened the emphasis on developing sustainable and equitable electricity tariffs. One notable development is the rise of self-sustaining dynamic tariffs, which use real-time data to reflect demand fluctuations more accurately (Aghahadi et al., 2024). At the same time, demand response programs are increasingly incorporating renewable energy sources, contributing to more environmentally friendly energy solutions (Aghahadi et al., 2024; Pawakul et al., 2020).

Artificial Intelligence (AI) and data analytics now play a pivotal role in the creation of dynamic pricing models within the energy sector. AI applications are used to determine retail electricity rates, enhance the effectiveness of demand response strategies, and optimize energy storage operations (Aghahadi et al., 2024). In this context, intelligent pricing models have been developed for electric vehicle charging, along with flexible pricing strategies for electricity retailers that take into account user demand patterns and the share of renewable energy in the grid (Aghahadi et al., 2024; Erdinc et al., 2020; Xie et al., 2021).

Challenges and Future Directions in Electricity Pricing in Iran

Iran's current electricity pricing structure faces significant challenges, largely due to widespread subsidies and market inefficiencies. These subsidies undermine incentives for energy efficiency and hinder investment in technologies like renewable energy, which remain economically unviable under existing policies. Although the concept of marginal cost pricing is theoretically recognized, its implementation has been limited by factors such as political pressures and public opposition to price increases. To address these issues, the Iranian government must undertake substantial reforms to establish a market that supports cost-reflective pricing while reducing unsustainable subsidies. A promising approach involves the gradual introduction of time-based tariffs and other smart pricing mechanisms that align electricity prices more closely with actual generation and distribution costs. Such measures can encourage more efficient decision-making by both consumers and producers.

In addition, creating a favorable environment for renewable energy investment is essential. Despite Iran’s significant potential in this area, investment remains limited due to flawed pricing mechanisms and the continued attractiveness of cheap fossil fuels. Implementing policies that offer competitive tariffs for renewable energy and phasing out fossil fuel subsidies could significantly boost investment in clean technologies.

In conclusion, future electricity pricing policies in Iran must emphasize economic efficiency, social equity, and environmental sustainability. Achieving these objectives will require comprehensive tariff reforms and regulatory stability to attract private sector investment and support the modernization and development of the country's electricity infrastructure.

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