

Perera, Pradeep; Sarker, Tapan; Nazmul Islam, K. M.; Belaïd, Fateh; Taghizadeh-Hesary, Farhad

## Working Paper

# How precious is the reliability of the residential electricity service in developing economies? Evidence from India

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**ADB Working Paper Series**

**HOW PRECIOUS IS THE RELIABILITY  
OF THE RESIDENTIAL ELECTRICITY  
SERVICE IN DEVELOPING  
ECONOMIES? EVIDENCE FROM INDIA**

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Pradeep Perera, Tapan Sarker,  
K. M. Nazmul Islam, Fateh Belaïd,  
and Farhad Taghizadeh-Hesary

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**Asian Development Bank Institute**

Pradeep Perera is a principal energy specialist at the South Asian Department of the Asian Development Bank. Tapan Sarker is an associate professor at the Department of Business Strategy and Innovation of Griffith University, Australia. K. M. Nazmul Islam is a postgraduate student at the Advance Water Management Center, School of Chemical Engineering of the University of Queensland, Australia, and Institute of Forestry and Environmental Sciences, University of Chittagong, Bangladesh. Fateh Belaïd is a professor at the Faculty of Management, Economics and Sciences of Lille Catholic University, Lille, France. Farhad Taghizadeh-Hesary is an associate professor at Tokai University, Japan.

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Please contact the authors for information about this paper.

Email: [tapan.sarker@griffith.edu.au](mailto:tapan.sarker@griffith.edu.au)

Asian Development Bank Institute  
Kasumigaseki Building, 8th Floor  
3-2-5 Kasumigaseki, Chiyoda-ku  
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500  
Fax: +81-3-3593-5571  
URL: [www.adbi.org](http://www.adbi.org)  
E-mail: [info@adbi.org](mailto:info@adbi.org)

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**Abstract**

This paper aims to examine the challenges of expanding access to an affordable electricity supply for rural households by addressing the subsidies and cost recovery of the existing tariff policy in the context of Uttar Pradesh (UP), India. The study used household survey data to assess the consumer attitudes, level of satisfaction, and affordability of electricity in rural areas of UP, where more than 78% of the state's population resides. Further, it examined the regulatory challenges of expanding access to the electricity supply to rural households in an affordable and fiscally sustainable manner. The main conclusions are that households have a higher level of satisfaction and willingness to pay as the supply duration has increased from 12–13 hours per day before 2017 to 15–18 hours per day. By contrast, the affordability of the lifeline level of consumption for people belonging to lower-income groups is low, and there is a need for continued fiscal subsidies to make the electricity affordable for this group of consumers. The case highlights that the prevailing electricity market, based on unmetered connections, a fixed monthly tariff, and a subsidy policy of fiscal transfers to the utility, is suboptimal in its targeting efficiency, incentives for energy conservation, and transparency of subsidy payments. The policy recommendations that this paper provides apply to developing countries that are reforming their electricity markets.

**Keywords:** affordability, access to electricity, regulatory framework, fiscal sustainability, India

**JEL Classification:** O12, O13, O53, Q41

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# 1. INTRODUCTION

Reliable and affordable electricity is critical for poverty reduction and to ensure sustainable development across any country (Barnes, Van Der Plas, and Floor 1997; Ouedraogo 2013). One of the Sustainable Development Goals (SDG) of the United Nations (i.e., SDG 7: Affordable and clean energy) is to provide reliable and affordable electricity (Rosenthal et al. 2018). The provision of affordable, reliable, and sustainable electricity is vital for ensuring well-being, which is also a prerequisite for achieving other SDGs (Büyükožkan, Karabulut, and Vicini 2018; Sinha, Sengupta, and Alvarado 2020). For example, electricity has a core role to play in reducing poverty (SDG 1), raising living standards by providing essential services like healthcare, education, water, and sanitation (SDGs 2–4, 6–7, and 9), raising household incomes (SDG 8), and creating resilient and sustainable communities (SDG 11) (Brecha 2019; Sinha, Sengupta, and Alvarado 2020). Nonetheless, many developing countries, particularly low-income countries in South Asia and the sub-Saharan African regions, face severe electricity shortages, leading to frequent load shedding. Several developing countries, particularly low-income countries in South Asia and parts of sub-Saharan Africa, often face severe power shortages, resulting in frequent power outages. A high level of technical deficiencies combined with underpricing of electricity services in these countries restricts the ability of utilities to recuperate capital and operating expenses, and the resultant lack of investment and maintenance affect the reliability of the electricity supply (Zhang 2019).

Examining individuals' access, electricity's affordability, and the electricity market's fiscal sustainability are, therefore, crucial for both setting regulatory policies and making electricity system planning decisions to enhance the power network's adequacy and reliability. This is particularly relevant in the rural residential sector in developing countries, where low affordability and low energy consumption make electricity cost recovery a problematic issue (Blimpo and Malcolm 2019).

This study assesses consumer attitudes, level of satisfaction, affordability, and sustainability of electricity consumption subsidies in rural areas. Our analysis setting is rural Uttar Pradesh in India, where more than 78% of the state's population resides. The Government of India (GoI) has expanded access to electricity as a means of alleviating poverty by enhancing economic development and living conditions, particularly for remote and rural households. Between 2000 and 2016, over 500 million people gained access to electricity, increasing the share of grid-electrified households from 43% to 82% (International Energy Agency-IEA 2017). While the pace of electrification has increased rapidly, with 40 million people gaining access to grid electricity each year since 2011, challenges remain for rural households due to (i) the internal wiring and connection costs and (ii) the unaffordability of monthly payments. Another reason is that the electricity network may not extend to the parts of villages where households with low income and social status reside (Planning Commission of India 2014). Thus, the GoI launched the Sahaj Bijili Har Ghar Yojana (SAUBHAGYA) in October 2017 to provide electricity connections to unelectrified households, the number of which is estimated to be close to 40 million (over 200 million people). It completed this scheme in March 2019 with over 28 million new connections, while 10–12 million households may have opted not to apply for an electricity connection (MoP 2017b).

Consequently, while India seems to have successfully met the challenge of physically connecting rural households to the electricity grid, providing rural households with reliable and affordable electricity in a financially sustainable manner remains a key challenge. This has resulted in unreliable grid-based electricity and frequent load shedding in rural areas. For instance, the distribution utilities supplying electricity to rural

areas have had to ration the supply hours and routine maintenance expenses for financial reasons. According to the Electricity Supply Monitoring Initiative (ESMI), only 16% of electrified rural households receive the full 6 hours of electricity during the peak period between 5 p.m. and 11 p.m. as the existing facilities and infrastructure are unable to meet the growing demand due to environmental, infrastructural, and financial limitations (Venkateswaran et al. 2018). On the other hand, significant financial investments and continuous fiscal subsidies are necessary to meet the capital and recurrent costs involved in providing electricity to the remote areas that households with low payment capacity inhabit (ADB 2007; Mahapatra, Chanakya, and Dasappa 2009; Pode 2013; Venkateswaran et al. 2018).

Given the high cost of the electricity supply to rural areas and the low affordability, the electricity utilities serving rural areas have resorted to the practice of rationing the supply duration to match the requirements and ability to pay of consumers and the fiscal space available for the government to subsidize the electricity utilities. Therefore, it is necessary to understand the value of various electricity attributes to household consumers and other users, which would enable policymakers to implement a sustainable electricity provision model for rural areas considering the concerns of both consumers and electricity utilities. Furthermore, there is a need to understand the relationships between income (affordability), the energy supply cost, and willingness to pay (Winkler et al. 2011; BuShehri and Wohlgenant 2012).

This paper attempts to fill the gap in the literature by addressing (i) the accessibility and affordability issue of rural households and (ii) the subsidies and cost recovery of the existing tariff policy in the context of Uttar Pradesh (UP), India. The key research question that motivates the goals mentioned above is, "What are the challenges of expanding access to the electricity supply to rural households in Uttar Pradesh in an affordable and fiscally sustainable manner?" The rationale for choosing UP as the case study location lies in the fact that it has the largest number of unelectrified households as of 2017, with a 45% electrification rate in rural areas (Graber et al. 2018). However, under the SAUBHAGYA scheme of the GoI, in Uttar Pradesh, 8 million rural households have received access to electricity since 2017.

The paper makes an original contribution in terms of the uniqueness of the empirical setting, the affordability evaluation, and the specific valuation scenario that the survey deployed. First, it examines rural household users' valuation attributes of electricity, like reliability (availability of electricity, quality, and hours of supply). Second, it measures households' level of satisfaction with attributes like the voltage, duration, supply tariffs and charges, payment facility, billing, and complaint redressal. Third, it estimates the willingness to pay (WTP) for an improved and reliable electricity supply and affordability (the price of the electricity) in a developing country context. Furthermore, the paper addresses the financial issues of supplying electricity to rural areas in Uttar Pradesh, cost recovery in the context of the prevailing regulatory regime for the electricity sector, and low affordability.

The results can inform energy policymakers to estimate socially and politically acceptable levels and fiscally sustainable tariffs in a developing country context. This work does not just attempt to inform the rural electricity sector in India; the lessons learned have the potential to help other developing countries, where a similar problem of low affordability and low willingness to pay exists. Furthermore, the results will allow policymakers, investors, and stakeholders to set sustainable tariffs by overcoming the key constraints, including low affordability and low willingness to pay.

The rest of the paper proceeds as follows. Section 2 reviews the existing literature. The following section reports the impacts of national electricity schemes on accessibility and

the financial system of the electricity companies (section 3.1), the tariff-setting framework (section 3.2), and the theoretical framework of the impacts of affordable and accessible electricity on the economy in Uttar Pradesh (section 3.3). Section 4 provides the methodological aspect of the study. Section 5 presents the results, and a discussion follows in section 6. Finally, section 7 concludes the paper by presenting the lessons learned and providing some policy recommendations on the tariff subsidy policy to improve rural electrification's affordability.

## 2. LITERATURE REVIEW

This study stems from three strands of research. The first body of knowledge consists of studies outlining the drivers of the energy demand in the residential sector (Bernard, Bolduc, and Yameogo 2011; Belaïd 2016, 2017). The analysis and modeling of the residential energy demand have been at the center of several pieces of research since the 1970s, following the first oil shock, particularly in developing countries (Lévy et al. 2014; Belaïd and Garcia 2016; Belaïd, Roubaud, and Galarotis 2019). These studies vary in terms of the concepts, approaches, estimation methods, and data that they used.

Different reasons motivated these considerable efforts to explore and understand the energy consumption patterns in the residential sector. This sector is one of the major contributors to the intensification of global energy consumption worldwide, representing more than a fourth of the total energy demand in many countries. There is a global consensus among policymakers that improving the energy efficiency in the residential sector may play an essential role in addressing poverty and inequality and mitigating global climate change (Belaïd 2018, 2019; Belaïd and Rault 2020; Belaïd et al. 2020).

Although studies on this subject are numerous in developed countries, they remain extremely rare in developing countries for various reasons. One of the main reasons is the lack of detailed data on household energy consumption (Adusah-Poku and Takeuchi 2019; Belaïd and Rault 2020).

Second, another stream of research consists of analyses outlining and exploring the validity of the energy ladder hypothesis (Farsi et al. 2007). This research's salient results have argued that household income, energy price, socioeconomic characteristics, and access to modern infrastructure are the main determinants of households' choice of cooking fuel. Thus, within this framework, this study contributes to the enrichment of knowledge on a subject that is extremely important for countries such as India, which is still seeking to improve access and provide affordable energy services for the entire population.

Third, our study makes an innovative empirical contribution to a rare but growing literature on drivers of individuals' WTP for improved and reliable residential electricity supply in developing economies (Abdullah and Mariel 2010; Oseni 2017).

Kateregga (2009) employed a contingent valuation approach to elicit households' willingness to pay for electricity outages in Uganda. The results showed that the key drivers of open-ended WTP are income and substitution costs. In the same vein, Twerefou (2014) examined individuals' WTP for a better residential power supply in Ghana as well as the main variables affecting the WTP. Based on a contingent valuation approach, this study claimed that Ghanaian households are willing to pay about one and a half times more than their current energy bill. Further, it highlighted that the main factors that affect households' WTP for a better electricity service are the household size, gender, income, and education level.



A recent study by Deutschmann, Postepska, and Sarr (2020) examined firms' and households' WTP for reliable electricity service in Senegal. Based on the nationally representative survey data, the findings substantiated that both firms and households are disposed to pay an additional premium over the current electricity prices for improved electricity service.

The previous literature focusing on India has examined (i) the price elasticity of electricity (Tiwari and Menegaki 2019); (ii) household energy poverty (Khandker, Barnes, and Samad 2010; Venkateswaran et al. 2018; Gupta, Gupta, and Serangi 2020); (iii) energy security and the sustainability of the electricity sector (Sarangi et al. 2019); and (iv) the association of electric power and economic development (Pachauri 1982). Bhide and Monroy (2011) also analyzed the impact of renewable energy technologies on reducing energy poverty, while Dhingra et al. (2008) reported access to clean energy services for the urban and peri-urban poor in India. On the other hand, studies have focused on electricity theft (Winther 2012). Oda and Tsujita (2011) examined the determinants of rural electrification based on discrete statistical modeling. In general, previous studies focusing on India have shown that electricity consumption depends on accessibility and affordability as well as other socioeconomic factors, such as income, family size, and family education (Oda and Tsujita 2011; Venkateswaran et al. 2018).

Furthermore, previous studies have reported the increasing energy security and economic growth aspect of affordable and accessible energy (Pachauri 1982; Sarangi et al. 2019). Blankenship, Wong, and Urpelainen (2019) conducted a randomized survey experiment to examine the determinant factors for the stated WTP for pricing reforms to improve India's power service supply. In addition to suggesting that low WTP is a major obstacle to price reform, the results showed that WTP is higher among respondents with greater social trust.

However, despite the existence of limited but growing literature, there is a study gap regarding the affordability of and accessibility to electricity for rural households, the fiscal sustainability of meeting the energy needs of rural consumers belonging to low-income groups, and the electricity market and tariff reforms necessary to achieve these seemingly conflicting objectives.

### **3. CONTEXT AND BACKGROUND**

#### **3.1 The Impacts of Recent National Electricity Schemes on Electricity Access and the Financial System of Electricity Companies in Uttar Pradesh**

India has achieved tremendous improvement in recent years in the provisioning of electricity access through the central Govt's flagship schemes, such as (i) Rajeev Gandhi Gram Vidyutkaran Yojana (RGGVY), (ii) Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY), (iii) the Integrated Power Development Scheme (IPDS), (iv) Ujwal DISCOM Assurance Yojana (UDAY), and (v) Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) (MoP 2014, 2017b, 2020a, b). Table 1 presents a brief overview of these schemes.

**Table 1: Overview of the Recent Electricity Supply Scheme in India**

Scheme Name	Year	Objective	Key Features
Rajeev Gandhi Grameen Vidyutkaran Yojana (RGGVY)	2005	Strengthening rural electricity distribution networks, including medium-voltage networks, to provide electricity to un-electrified villages with a population of 100 and above.	<ul style="list-style-type: none"> <li>The Central Gol implemented the scheme through the Rural Electrification Corporation (REC).</li> <li>The total cost under this scheme is an estimated Rs 37.86 billion for 5 years.</li> <li>This scheme has electrified around 29,351 villages and 3,257,471 households.</li> </ul>
Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY)	2014	Strengthening the sub-transmission and distribution infrastructure, including metering at all levels in rural areas through rural household and agricultural feeder separation.	<ul style="list-style-type: none"> <li>The newly elected Central Gol continued the previous RGGVY scheme under this scheme.</li> <li>The Central Gol heavily subsidized this scheme and provided 60% of the project cost as a grant.</li> <li>The allocated additional funding is around Rs 823 billion for 8 years (2014/15 to 2021/22).</li> <li>Electrification is complete in around 395,132 villages.</li> </ul>
Integrated Power Development Scheme (IPDS)	2014	Strengthening the distribution network in urban areas and introducing some smart grid features.	<ul style="list-style-type: none"> <li>The Central Gol and other states' government implemented this scheme.</li> <li>The total cost under this scheme is an estimated Rs 326.12 billion.</li> </ul>
Ujwal Discom Assurance Yojana (UDAY)	2015	The scheme envisaged (i) financial turnaround of electricity distribution companies (DISCOMs) through debt restructuring, operational efficiency improvements, and reduction of generation costs; (ii) development of renewable energy; and (iii) energy efficiency and conservation.	<ul style="list-style-type: none"> <li>States took over 75% (2015), 50% (2016), and 25% (2017) of the DISCOM debt.</li> <li>States could issue bonds of 10–15 years maturity to take over the debt and transfer the proceeds to DISCOMs through a combination of grants, loans, and equity.</li> <li>Some of the activities included feeder metering, DT metering, consumer indexing, GIS mapping, and smart meters for the consumers.</li> </ul>
Sahaj Bijli Har Ghar Yojana (SAUBHAGYA)	2017	To electrify all households in India that apply for electricity connection.	<ul style="list-style-type: none"> <li>The central Gol provided the funds for the scheme to all states.</li> <li>The total cost under this scheme is an estimated Rs 163.2 billion, with a Rs 140.25 billion outlay for rural households and a Rs 22.95 billion outlay for urban households.</li> <li>As of January 31, 2020, this program is substantially complete, with over 26 million new household electricity connections.</li> </ul>

Source: Authors' compilation.

These schemes have achieved 100% village electrification and electrified over 100,000 villages from 2005 to 2018. Despite the allocation of considerable resources to expanding the reach of the electricity distribution network, 40 million households (i.e., 200–250 million people) were not connected to the electricity grid as of August 2017. This was partly because the objective of the DDUGJY scheme was village electrification

as opposed to household electrification. It is considered a village to be electrified if it is connected to the medium-voltage (11 kV) network and the public buildings within the village, and at least 10% of the households have access to electricity. The SAUBHAGYA scheme completed 8 million new rural connections in Uttar Pradesh. This scheme increased the number of electrified households in Uttar Pradesh from 21 million to 29 million, most of which are poor rural households (MoP 2017b).

On the other hand, under the UDAY scheme, the state Government of Uttar Pradesh has entered into a memorandum of understanding (MOU) with the central Gov. The MOU has broadly set the roadmap for financial and operational performance improvement in participating states' electricity sector (MoP 2020b). Hence, the Government of Uttar Pradesh took on over 75% of the outstanding debt, amounting to Rs392 billion (approximately \$5.5 billion) (as of 30 September 2015) of Uttar Pradesh Power Corporation Ltd (UPPCL), on 30 January 2016 of the UPPCL (and its DISCOMS) in the form of a combination of equity (Rs98 billion), grants (Rs196 billion), and interest-free loans (Rs 98 billion). This exercise reached completion on 31 March 2017 (ADB 2020).

Consequently, the financial position of the UPPCL improved in FY2016 and FY2017 due to the reduction of the interest cost as a result of the conversion of interest-bearing loans to equity, grants, and interest-free loans. However, the financial position of the UPPCL has deteriorated since FY2018 due to the UPPCL's inability to achieve the operational performance improvement that the Uttar Pradesh Electricity Regulatory Commission (UPERC) and UDAY set and the consequent excess expenditure incurred over that allowed by the UPERC. It again financed the resultant financial loss and cash gap with short-term loans and reversed the saving from the interest cost that it had achieved due to the UPPCL's financial restructuring of liabilities in 2016–17. Besides, under the UDAY MOU, the UPPCL needed to achieve several performance targets in 2019, such as (i) a reduction in the aggregate technical and commercial (ATC) losses from 35.25% in fiscal year (FY) 2015/16 to 15% by FY2020/21 and (ii) a reduction in the gap between the average cost of supply (ACS) and the average revenue realized (ARR) from Rs1.76 per kilowatt-hour (kWh) in FY2015/16 to Rs0.0 per kWh in FY2020/21. To achieve these targets, the UPPCL has agreed to implement the following series of measures to improve its operational performance:

- a. Conversion of all household connections to metered connections;
- b. Strict enforcement of bill collection from large commercial, industrial, and government consumers;
- c. Segregation of medium-voltage feeders supplying unmetered agriculture consumers who use electricity for water pumping from those supplying residential consumers and restriction of the duration of the electricity supply in feeders supplying PTW consumers;
- d. Installation of smart prepaid meters in urban areas and engagement of billing agents;
- e. Conversion of rural distribution lines to Aerial Bundle Conductors (ABC) to prevent illegal connections;
- f. Appointment of community-based bill collection agents, including women's self-help groups;
- g. Installation of smart meters in urban areas; and
- h. Regular energy auditing at the feeder and distribution transformer levels.

However, the above measures are based on the presumption that rural consumers can make timely electricity bill payments due to strict bill collection procedures. Hence, the current approach involves the enforcement of payment and theft prevention. It does not consider the critical issue of affordability and paying capacity of rural poor households and agricultural consumers.

### 3.2 Tariff-Setting Framework in Uttar Pradesh

The UPERC decided the distribution tariff in Uttar Pradesh for April 2015 to March 2020 for various consumer categories following the guidelines published in 2013 (UPERC 2013). The expectation is that the UPPCL and its subsidiaries will recover the eligible expenses incurred in supplying electricity and earn a reasonable return on equity on the equity capital that the state government invested in the UPPCL. The UPERC determines the aggregate revenue requirement (ARR) of the UPPCL based on a tariff filing that the UPPCL submits, and the ARR sets a ceiling of regulated revenues allowed for the UPPCL in a given financial year. The eligible expenses include: (i) the cost of the allowed quantity of power to meet the demand from long-term power purchase agreements that the UPERC has approved and transparent short-term power purchase from the Indian power market; (ii) the cost of allowed distribution losses based on normative standards that the UPERC has stipulated; (iii) the operation and maintenance cost following norms that the UPERC has set; (iv) the interest cost of loans that the UPERC has taken out for approved capital assets and approved working capital; (v) the depreciation of capital assets recognized by the UPERC; and (vi) the return on equity contributions that the UPERC recognizes at the rate of 16% (MoP 2006).

The UPERC determines the individual tariffs for different consumer categories after considering socio-economic issues, including affordability, competitiveness (i.e., mainly for industrial consumers for whom electricity is a significant input cost), and fairness. The UPERC allows a certain degree of cross-subsidization from industrial and commercial consumers to rural residential consumers and pumped tube well consumers (i.e., agriculture). However, the options available for large consumers to have captive power plants (i.e., power plants that industrialists own and dedicate to supplying industrial consumers) or to resort to direct purchases from power plants using the open-access regime (i.e., bypassing the UPPCL, purchasing power directly from a generator, and paying only a network usage fee for the use of the network for power purchases) limit the extent of cross-subsidization (UPERC 2013).

Due to the limitations on the extent of feasible cross-subsidies and the presence of many rural consumers with limited affordability, the tariffs for rural residential and agricultural consumers are below the cost recovery level. The expectation is that the government will provide the UPPCL with a direct revenue subsidy to bridge the gap between the cost of supply and the gazetted tariff, including the cross-subsidy, and that the billed revenue plus the revenue subsidy will equal the approved ARR for a given year. If there is an under-recovery of revenues for reasons that are not within the control of the UPPCL, it can address such under-recovery through an adjustment to the tariffs in the following years, and this appears as a regulatory asset on the balance sheet of the UPPCL. This includes instances like lower sales to certain consumer categories due to weak demand. However, it is not permissible to recover losses due to inefficiencies on the part of the UPPCL through future tariff adjustment (UPERC 2013).

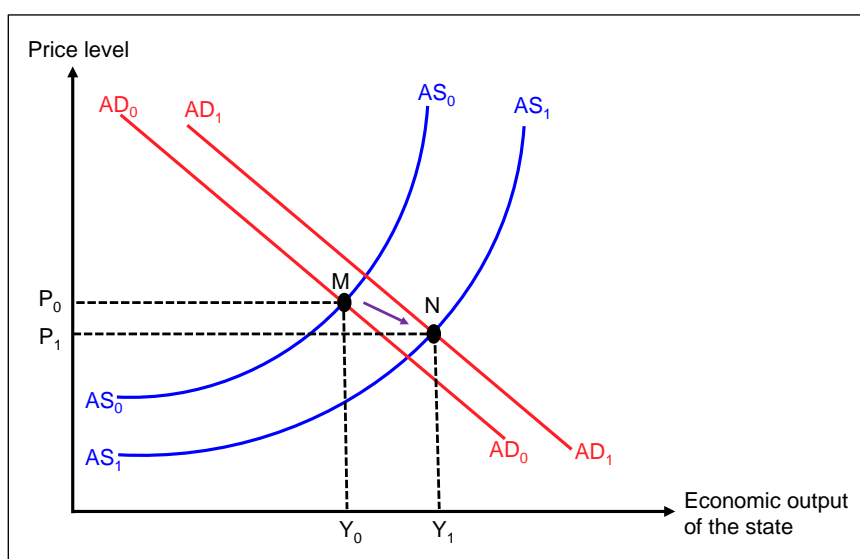
## 4. MATERIAL AND METHODS

### 4.1 Theoretical Framework of the Impacts of Affordable and Accessible Electricity on the Economy

This sub-section explains the transmission channel and the effect of increasing the accessibility to and affordability of electricity using a simple aggregate supply and demand model, as Figure 1 shows. In Figure 1, the economy of the UP is initially in equilibrium with the price level,  $P_0$ , and the real output level,  $Y_0$ , at point M. AD and AS, respectively, represent the aggregate demand curve and the aggregate supply curve. The increasing accessibility and affordability will influence the economy of the UP by shifting  $AS_0$  to  $AS_1$  and  $AD_0$  to  $AD_1$ . On the supply side of the state economy, electricity is an input to production (Pachauri 1982), so the falling electricity price (affordability) and easier access (accessibility) will increase the electricity input in production, which in turn will increase the economic output (Hartono et al. 2020).

Besides, there will be a spillover effect on other production inputs, such as labor and capital, from increasing the marginal productivity (Koirala et al. 2019; Yoshino, Taghizadeh-Hesary, and Nakahigashi 2019) and total factor productivity (Bloom, Schankerman, and Van Reenen 2013; Lewis and Severnini 2020; Wen et al. 2020). On the other hand, on the demand side of the economy, it will increase the consumption level of the households and the AD (Mensah, Marbuah, and Amoah 2016). In combination, this moves the UP economy to the level of output ( $Y_1$ ) and the price level ( $P_1$ ). Figure 1 indicates this point at point N.

**Figure 1: The Transmission Channel and the Effect of Increasing Accessibility and Affordability on the Economy of Uttar Pradesh**



Source: Authors' depiction.

As we have explained, increasing affordability and accessibility will increase the electricity consumption both on the supply and on the demand side of the economy, and it is a matter of fact that the electricity supply will have a regional spillover effect (Taghizadeh-Hesary and Yoshino 2018) because the electricity supply will increase the regional production, sales of businesses, and real estate prices and overall will increase

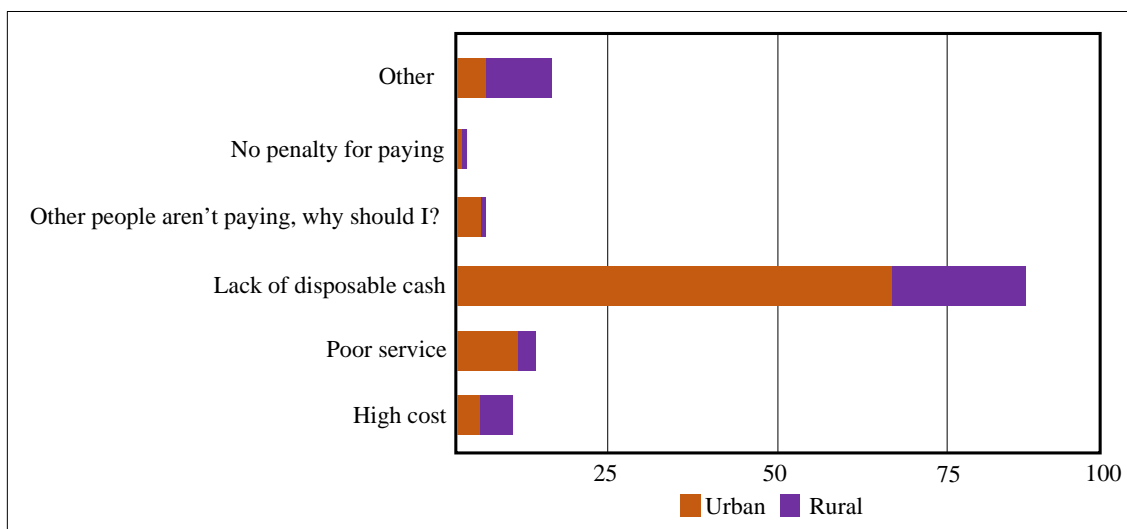
the gross domestic product (GDP) of UP. Hence, the state government can collect more taxes from businesses and property owners in the form of income tax, profit tax, property tax, and so on. Hence, in the long run, increasing the affordability and accessibility of electricity will improve the state government’s fiscal status (Yoshino, Taghizadeh-Hesary, and Nakahigashi 2019).

## 4.2 Study Area Description

Uttar Pradesh is the most populous state of India. It had a population of approximately 200 million in 2011, which is 16.5% of India’s total population, and 78% of the state’s population resides in rural areas. With an estimated population of about 228 million in 2019, 47% of which is female, Uttar Pradesh accounts for slightly less than a sixth of the national population. Approximately 78% of the state’s population resides in rural habitations. Agriculture and the related sectors are the most extensive economic activity, comprising almost 22% of the state’s GDP, followed by manufacturing, construction, and tourism. About 70% of UP’s residents directly or indirectly depend on agriculture and associated sectors (IISD 2018). The state lags most other states in India in terms of the development indicators and records uneven progress across social groups, with stark differences in educational attainment, types of jobs, and access to electricity and clean drinking water across social groups. The scheduled castes (i.e., the caste groups with lower socioeconomic development) have a very high poverty rate, amongst the highest in the country (World Bank 2016).

Almost 75% of the households in Uttar Pradesh live in rural areas. As of 2017, almost 75% of rural domestic households’ consumers were unmetered and under a fixed price regime (MoP 2017a). An IISD study in 2018, based on a quantitative survey of 1917 households, showed that only 25% of rural households had a meter installed (compared with 85% in urban areas) (IISD 2018). Of those rural households with a meter, only 40% of bills were based on the reading of that meter, meaning that less than 10% of the rural population was paying for grid electricity according to the installed meter. The survey also showed that urban consumers have a better track record in usually paying their bills on time (81%) than rural consumers (49%). About 40% of rural consumers indicated that they only “sometimes” pay their bills on time (Figure 2).

**Figure 2: Consumers’ Attitudes Regarding Payment for Electricity**



Source: IISD (2018).

### 4.3 Questionnaire Design and Survey Implementation

To ensure that the samples were representative, the researchers conducted the questionnaire surveys based on the following criteria: (a) all habitations are from the SAUBHAGYA program intervention area; (b) habitations that have active women-led entrepreneurship initiative, handicraft, and weaving clusters. The study used quota sampling for households to ensure adequate representation of different social, economic, gender, and ability attributes of households and their members.

The household survey questionnaire consisted of five parts. The first part collected geographic and demographic information. The second part investigated household-related data. The respondents reported the type of house they live in and the number of rooms in the house. The third part investigated electricity consumption-related data. The final part aimed to analyze households' satisfaction and their willingness to pay data. The household survey covered 840 households (432 households in Varanasi district and 408 households in Lucknow district). The study adopted a mixed-methods approach involving the household survey, key informant interviews (KIs), and focus group discussions (FGDs) in Uttar Pradesh in early 2019 in preparation for this study. The researchers conducted a pre-test survey to determine the most suitable survey formats. KIs were conducted with either the Gram Panchayat Sarpanch or any other person who the researchers identified as having a strong understanding of the habitation. Also, eight FGDs took place with four male and four female participants. The supplementary materials include the survey questionnaire.

### 4.4 Methodology for Assessing the Affordability of Electricity

The study estimated affordability following two approaches. One was to use the World Bank's affordability index, and the other one relied on household expenditure. The World Bank defined affordable electricity as an amount that is no more than 5% of a household's income (Kojima and Trimble 2016). Therefore, using this value, equation 1 determines affordability.

$$\text{CoE}_{\text{af}} = I_{\text{hh}} \times F_{\text{af}} \quad (1)$$

Here,  $\text{CoE}_{\text{af}}$  represents the cost of affordable electricity.  $I_{\text{hh}}$  represents household income.  $F_{\text{af}}$  represents the affordability factor, which is 5%. According to the *Atlas of Household Energy Consumption and Expenditure in India* (Woodbridge, Sharma, and Fuente 2011), households spend 10% of their income on energy consumption in both the rural and the urban areas in India, while electricity constitutes 64% of the final household energy consumption in India. Hence, we also used this value to determine the affordability based on equation 2.

$$\text{CoE}_{\text{af}} = I_{\text{hh}} \times \text{IE}_{\text{hh}} \times \text{ES}_{\text{hh}} \quad (2)$$

Here,  $\text{CoE}_{\text{af}}$  represents the cost of affordable electricity.  $I_{\text{hh}}$  represents household income.  $\text{IE}_{\text{hh}}$  is the household income spent on energy consumption, which is 10%.  $\text{ES}_{\text{hh}}$  stands for the share of electricity in energy consumption, which is 64%.

## 5. RESULTS

### 5.1 Socio-economic Characteristics of the Respondents

Table 2 summarizes the socio-economic data. There were more female (58%) than male (42%) respondents, and people in the age range of 31–40 years accounted for a large portion of the participants (~31%). Respondents with an education level of class 5 to class 12 constituted the highest number (56%) of respondents. Among all the respondents, 47% were the chief wage earner of the family, while 42% were a housewife. Families of six people or more generally included grandparents living with their grandchild/children (~54%). Most of the respondents were daily laborers (~40%), followed by those who were running their own business (10%). Respondents with a monthly household income between Rs5,000 and Rs10,000 were the largest group (51%), followed by those with Rs2,250–5,000 (34%). Approximately 55% of the respondents' monthly household expenditure was in the range of Rs2,250–5,000, and 44% of the respondents had used grid electricity for over 3 years.

**Table 2: The Descriptive Characteristics of the Survey Respondents**

Index	Variable	Number of Samples	Percentage
District	Lucknow	408	49%
	Varanasi	432	51%
Distribution companies	MVVNL	408	49%
	PuVVNL	432	51%
Block	Arajiline	80	10%
	Baragaon	80	10%
	Gosainganj	78	9%
	Harhua	112	13%
	Kakori	86	10%
	Kashi Vidya Peeth	80	10%
	Mall	80	10%
	Mohanlalganj	81	10%
	Pindra	80	10%
	Sarojaninagar	83	10%
	Gender	Male	355
Female		485	58%
Age	Below 20	5	0.60%
	21–30	110	13.10%
	31–40	262	31.19%
	41–50	236	28.10%
	>50	227	27.02%
Education	Illiterate	185	22%
	Up to class 4	87	10%
	Class 5 to 12	470	56%
	Graduate	79	9%
	Postgraduate and above	19	2%

*continued on next page*



**Table 2** *continued*

Index	Variable	Number of Samples	Percentage
Respondent's role in the family	Chief wage earner	392	47%
	Housewife	350	42%
	Working member	61	7%
	Studying member	11	1%
	Dependent on other earning member	26	3%
Number of family members	1	4	0.5%
	2	15	1.8%
	3	44	5.2%
	4	130	15.5%
	5	192	22.9%
	≥6	455	54.2%
Profession	Agriculture on own land	276	32.86%
	Casual agricultural labor	29	3.45%
	Cattle rearing	1	0.12%
	Cultivation on leased land	12	1.43%
	Daily laborer	343	40.83%
	Own business	84	10.00%
	Salaried permanent job	68	8.10%
	Salaried seasonal job	23	2.74%
	Other (politician/pension holder)	4	0.48%
Monthly household income	< Rs2,250	22	3%
	Rs2,250–5,000	284	34%
	Rs5,000–10,000	429	51%
	Rs10,000–25,000	89	11%
	> Rs25,000	16	2%
Monthly expenditure	< Rs2,250	80	10%
	Rs2,250–5,000	459	55%
	Rs5,000–10,000	241	29%
	Rs10,000–25,000	60	7%
Duration of electricity connection	0–1 year	224	27%
	1–3 years	244	29%
	Over 3 years	372	44%

Source: Authors' compilation from the survey.

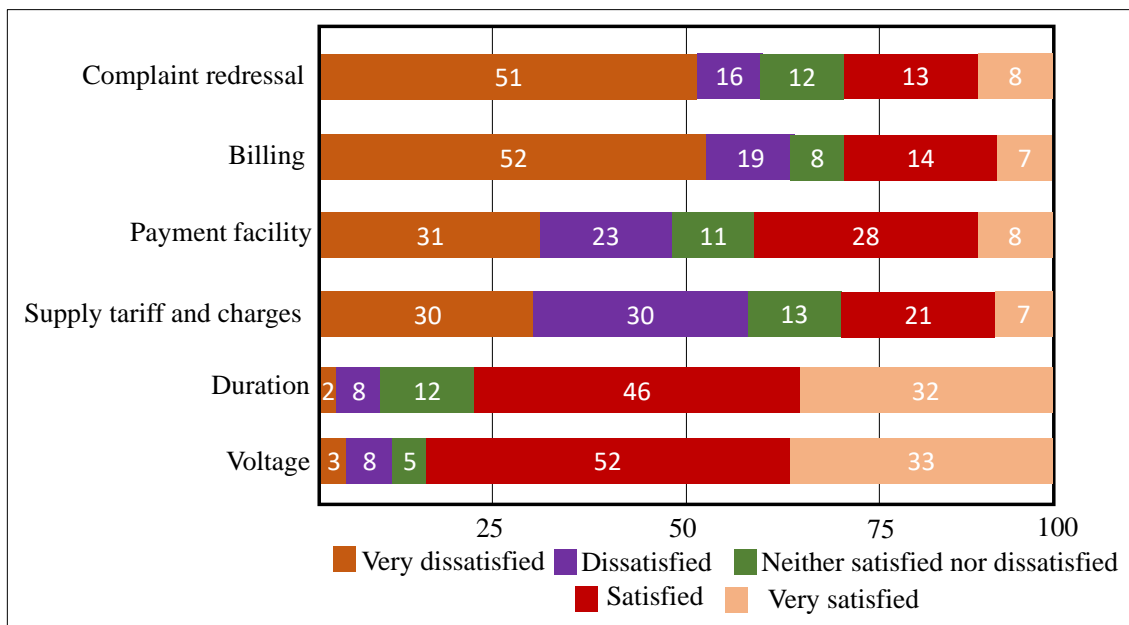
## 5.2 Survey Findings on Consumers' Attitudes the Existing Supply

The results of the analysis point out several interesting dimensions regarding the accessibility of electricity in Uttar Pradesh. Over 80% of the connected rural and urban households used electricity for lighting, fans, cell phones, and TV and radio. The majority of the households received 15–18 hours of electricity supply per day. Around 68% of the respondents reported 3–6 hours of load shedding per day. A significant proportion of the households (22%) also reported that load shedding lasts for up to 6–9 hours per day. Most of the respondents (97%) reported unplanned load shedding with no prior notification. Overall, the electricity supply is less reliable during the morning hours (6 a.m. to 9 a.m. and 9 a.m. to 12 p.m.).

The study also analyzed the households' level of satisfaction with the voltage, duration of supply, tariff and charges, payment facility, billing, and complaint redressal mechanism. The researchers observed a higher level of household satisfaction with the voltage and duration of supply. The households reported that the supply duration had increased from 12–13 hours per day before 2017 to 15–18 hours per day. However, the satisfaction level was lower for the level of tariff and charges, payment facility, billing, and complaint redressal mechanism (Figure 3).

While the study found that awareness of LED lights as an electricity-saving option is relatively high among both men and women, awareness of CFL lights and their electricity-saving use is low (34% for men and 38% for women). Further, awareness of the use of lights with a higher energy star rating is relatively low. All the households that the survey covered are connected to the grid and have a sanctioned load of 1 KW, and 93% of the households have a metered connection. Households reported that, since their meter's installation, they have become more conscious about consuming electricity and turn off lights and fans when they are not needed. Most households have converted to metered connections in the past six months. The average monthly expenditure for households with a metered connection is lower than that for households with a non-metered connection. The average monthly bill for households with a non-metered connection is Rs650, while the average monthly bill for households with a metered connection is Rs379.

**Figure 3: Level of Satisfaction of Households Regarding Various Parameters of the Electricity Supply**



Source: Authors' depiction from the analysis.

### 5.3 Concerns about Billing, Collections, and Complaint Redressal Mechanisms

Other studies have also highlighted the issues of billing and collection. In a survey covering 541 households in Uttar Pradesh,<sup>1</sup> 14%–29% of consumers mentioned that they had paid electricity bills only once in the last six months (KPMG 2018). Another study, which Jain et al. (2018) undertook in 2018, showed that as many as 40% of metered households were not paying their bills. The main reasons for this are the delay in receiving electricity bills and, in some cases, the inability of some consumers, who do not have a regular/monthly source of income (such as farmers who prefer to clear their dues when farm outputs are sold in the market), to pay. This study also observed a low level of consumer satisfaction with the billing and complaint redressal mechanisms. Specific problems that the households mentioned were:

- a. Frequent meter malfunctions;
- b. Highly inflated erroneous bills (for example, receiving a bill without an electricity connection) and notices for one-time settlement of erroneous bills, which the respondents viewed as unfair;
- c. Not receiving a bill on time, affecting the ability to pay the bill on time; and
- d. Irregular checking of the meters by the staff of the electricity distribution companies.

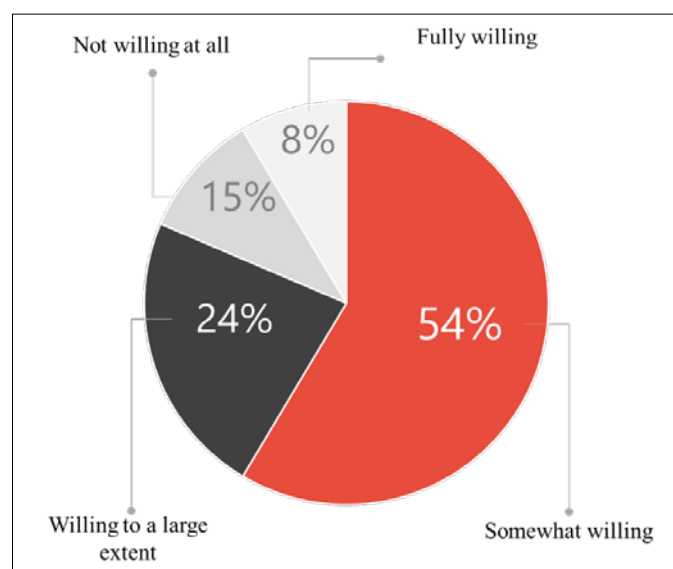
### 5.4 Respondents' Willingness to Pay and Affordability

The study revealed consumers' willingness to pay for an improved and reliable power supply. Only 8% of the respondents were willing to pay for an improved and reliable electricity supply without any additional concerns. Another 24% were willing to pay a higher amount provided that there will be improvements and the reliable electricity supply and improvements will not be temporary but permanent. More than half (54%) of the respondents were somewhat willing to pay for an improved and reliable power supply, and 15% of the respondents were not willing to pay a higher amount at all (Figure 4).

About 23% of the respondents were willing to pay up to Rs200 per month for electricity, a further 50% were willing to pay up to Rs400 per month, and only 16% were willing to pay more than Rs500 per month. It can be deduced that about 23%–35% of the population is willing and able to pay around Rs200 per month. This is also roughly equal to the estimated percentage of people living below the national poverty line (Rs30 per day per capita or Rs5, 000 for a household of 5.5 people), which is about 30% of the population in Uttar Pradesh. This indicates that the current fixed charge for unmetered households is beyond the level that poor households can afford, and are better off converting to a metered connection (Table 3).

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<sup>1</sup> In total, the study covered 2201 households in Uttar Pradesh, Rajasthan, Bihar, and Odisha.

**Figure 4: Households' Willingness to Pay for an Improved Power Supply**

Source: Authors' depiction from the analysis.

**Table 3: Distribution of Households According to the Willingness to Pay for Electricity in a Month**

Amount Paid (Rs)	Percentage of Respondents from East UP	Percentage of Respondents from Central UP	Overall Percentage
Up to 100	1%	1%	1%
100–200	4%	32%	22%
200–300	20%	31%	27%
300–400	38%	14%	23%
400–500	22%	6%	12%
>500	14%	17%	16%

Source: Authors' compilation from the survey.

The researchers observed that the average affordable amount for electricity is 228 Rs/month for the income bracket <Rs5,000/month, while, for the majority of the population (51%) belonging to the income bracket Rs5,000–10,000 per month, the average affordable amount for electricity is Rs456/month (Table 4).

**Table 4: Affordability of Electricity and Income Level**

Income Bracket (Rs/Month)	Median Income (Rs/Month)	% of Population	Affordability Amount for Electricity (Rs/Month)		
			Method 1	Method 2	Average
<5,000	4,000	36	200	256	228
5,000–10,000	8,000	51	400	512	456
>10,000	13,000	13	650	832	741

Source: Authors' compilation from the analysis.

The households belonging to the middle category of monthly income, in the bracket of Rs5,000 to Rs10,000, are willing and able to make a monthly payment of around Rs456, which is in the range of the prevailing fixed charge for unmetered consumers. Table 5 shows the consumption level of different electricity appliances at different levels of monthly expenditure for metered consumers. For poor households (monthly income below Rs5,000), paying Rs200 per month would enable consumption of 33 kWh/month at the prevailing tariff, which we can consider to be adequate to meet their basic energy needs. Meanwhile, relatively better-off households (monthly income of Rs5,000–Rs10,000) can spend up to Rs500, which would enable energy consumption of 119 kWh/month.

**Table 5: Expenditure and Consumption Levels at Prevailing Electricity Tariffs**

Amount of Monthly Tariff a Household is Willing to Pay (Rs/Month)	Expected Consumption (at the Present Tariff Level)	Possible Basket of Energy Services at the Consumption Level
100	2.99	2 LED lights (5 hrs/day)
200	32.84	4 LED lights (5 hrs/day), 1 fan (6 hrs/day), mobile charging (5 hrs/day), TV (3 hrs/day)
300	62.69	5 LED lights (5 hrs/day), 2 fans (10 hrs/day), mobile charging (5 hrs/day), TV (3 hrs/day), 1 electrical appliance (1 hr/day)
500	119.48	6 LED lights (5 hrs/day), 3 fans (10 hrs/day), mobile charging (6 hrs/day), TV (5 hrs/day), 1 electrical appliance (1 hr/day)

Source: Authors' compilation from the analysis.

## 5.5 Cross-subsidies, Cost Recovery, and Electricity Tariff Policy

### 5.5.1 Cost Recovery under the Prevailing Tariff Regime

An analysis of revenue recovery from different consumer categories of the UPPCL shows that rural domestic consumers contribute 21% of energy consumption, but their contributions to revenue billed, and revenue realized are 12% and 11%, respectively (UPERC 2019). The relative contribution of rural domestic consumers is likely to increase further when considering fully the 8 million new SAUBHGAYA consumers' consumption.<sup>2</sup>

The average billing rates of rural domestic metered consumers, unmetered consumers, and agriculture consumers were 2.96 Rs/kWh, 3.73 Rs/kWh, and 1.82 Rs/kWh, respectively. These billing rates are significantly lower than the average cost of supply of 7.74 Rs/kWh. Only the industrial and commercial consumers and public institutions have a higher billing rate than the average cost of supply. This indicates a modest cross-subsidization level from industrial and commercial consumers to residential and agricultural consumers (Table 6).

There is an expectation that the government will provide the difference between the billed revenue and the average cost of supply for subsidized consumer categories (e.g., rural domestic and agriculture) as a revenue subsidy. As Table 6 shows, the Uttar Pradesh Government has paid a substantial portion of this subsidy and subsidized

<sup>2</sup> Most of these consumers were connected during FY2019, and the FY2019 figures do not fully capture their consumption.

the electricity companies to a certain extent. However, with the addition of a further 8 million rural domestic consumers, the subsidy requirement is likely to increase by a further Rs35–Rs40 billion, and the total subsidy requirement is likely to be in the range of Rs130 billion to Rs150 billion (0.7%–0.9% of the state GDP), and this will probably increase the fiscal stress of the state government.

**Table 6: Analysis of Revenue Recovery from Different Consumer Categories in FY 2019**

Consumer Category	Electricity Sales (GWh)	Share of Total Consumption (%)	Revenue Billed (Rs Billion)	Billing Rate (Rs/KWh)	Revenue Collected (Rs Billion)	Revenue Realized (Rs/KWh)	Collection Ratio (%)
Rural domestic (metered)	8,951	10.3	26.47	2.96	16.46	1.84	62.2
Rural domestic (unmetered)	9,252	10.7	34.5	3.73	29.25	3.16	84.8
Urban domestic (metered)	21,277	24.6	126.98	5.97	115.91	5.45	91.3
Agriculture (PTW)	13,462	15.6	24.47	1.82	21.29	1.58	87.0
Commercial	6,285	7.3	59.02	9.39	56.49	8.99	95.7
Industrial	15,266	17.6	126.31	8.27	116.16	7.61	92.0
Public services	12,027	13.9	107.91	8.97	72.82	6.05	67.5

Source: Authors' analysis based on data from the UPPCL.

In terms of revenue realized, the revenue gap (i.e., the difference between the revenue realized and the average cost of supply) becomes even wider as the collection efficiency (i.e., the percentage of billed revenue collected) is relatively low for domestic and agricultural consumers. The cost recovery (i.e., the revenue collected as a percentage of the cost of supply) for rural domestic metered, rural domestic unmetered, and agricultural consumers is 23.8%, 40.8%, and 20.4%, respectively (Table 6). The actual cost recovery for unmetered consumption from unmetered domestic and agricultural consumers is likely to be even lower as it does not capture such consumers' overconsumption in addition to their assumed consumption. The UPPCL, using short-term borrowing, has to finance the resulting cash flow gap due to the uncollected electricity bills and any shortfall in revenue due to the fiscal constraints.

### 5.5.2 Tariff Reforms Undertaken from 2015 to 2019

There have been several tariff adjustments during the period 2015 to 2019 to address the anomalies in the tariff structure and improve the cost recovery from rural domestic consumers<sup>3</sup> (Table 7). Notably, there were no tariff adjustments in 2017 and 2019 because of the Uttar Pradesh State elections and the Indian national elections in these two years. There has been a concerted effort to convert all the unmetered rural household connections into metered connections with the tariff adjustments. These tariff reforms have attempted to achieve three main objectives: (i) encourage unmetered consumers to move to a metered connection; (ii) maintain the lifeline tariff at a relatively low level of consumption below 100 kWh/month; and (iii) gradually increase the tariff for customers consuming more than 100 kWh/month to the cost recovery level.

<sup>3</sup> UPERC Government of Uttar Pradesh, Annual Tariff Orders in 2015, 2016, 2018, and 2019.

**Table 7: Fixed Tariff for Unmetered Consumers**

Year	Fixed Charge (Rs/Month)	Breakeven Consumption to Metered (KWh/Month)
2015	200	68.2
2016	200	68.2
2017	200	68.2
2018	300	73.3
2019	400	105.7
2020	500	119.5

Source: Authors' compilation from the analysis.

There has been a gradual increase in the monthly fixed charge for unmetered domestic consumers from Rs200 in 2015 to Rs500 in 2020 (250%). Simultaneously, the lifeline tariff applicable to metered domestic consumers has increased from 2.20 Rs/kWh to 3.35 Rs/kWh (52%). The relatively larger increase in the fixed tariff applicable to unmetered consumers compared with the increase in the energy charge for metered consumers acts as an incentive for unmetered consumers to opt for a metered connection. This also implies that the crossover consumption that makes the consumers better off with an unmetered connection has increased from 68.2 kWh/month to 119.5 kWh/month. Estimations have indicated that the average monthly consumption in rural areas in Uttar Pradesh is around 80 kWh/month, and this gives an incentive to such consumers to opt for a metered connection (Table 8).

**Table 8: Tariffs for Rural Metered Consumers**

Year	Fixed Charge (Rs/Month)	Energy Charge (Rs/kWh)				
		0–100 kWh	100–150 kWh	150–300 kWh	300–500 kWh	500 kWh >
2015	50	2.20	2.20	2.20	2.20	2.20
2016	50	2.20	2.20	2.20	2.20	2.20
2017	50	2.20	2.20	2.20	2.20	2.20
2018	80	3.00	3.50	4.50	5.00	5.50
2019	80	3.00	3.50	4.50	5.00	5.50
2020	90	3.35	3.85	5.00	5.50	6.00

Source: Tariff notifications by the UPERC.

The electricity tariff applicable to metered consumers also gradually increased from 2015 to 2020. The tariffs applicable to higher consumption blocks have increased faster than the lifeline tariff applicable to consumption below 100 kWh/month. The monthly expenditure of metered consumers using 80 kWh/month increased from Rs226 to Rs358 from 2015 to 2020, representing an average annual increase of 9.7%, whereas the monthly consumption for rural consumers using 550 kWh/month increased from Rs1,300 to Rs2,788, representing an average annual increase of 16.3%. This also compares with the average annual increase in fixed charges for unmetered consumers from Rs200 to Rs500, representing an average annual increase of 21.1%. This shows that the last 5 years' tariff increase has attempted to discourage unmetered consumption and monthly consumption over 200 kWh/month (Table 9).

**Table 9: Monthly Electricity Expenditure for Different Levels of Consumption**

Monthly Consumption (KWh/Month)	Monthly Electricity Bill in 2015 (Rs/KWh)	Monthly Electricity Bill in 2018 (Rs/KWh)	Monthly Electricity Bill in 2020 (Rs/KWh)	Annual Average Increase (%)
80	226	320	358	9.7
200	490	780	868	12.1
350	850	1,480	1,643	14.1
550	1,300	2,280	2,768	16.3

Source: Authors' compilation from the analysis.

## 6. DISCUSSION

### 6.1 Implications of Increasing the Affordability of and Accessibility to Energy Security

This study focuses on the affordability and accessibility of electricity, the two main pillars of energy security, in rural areas of Uttar Pradesh (Malik et al. 2020). An adequate and reliable supply of energy resources and reasonable energy prices are two of the key energy security criteria (Bielecki 2002). The affordability dimension of energy security represents a community's ability to obtain energy resources at a reasonable price, while the accessibility dimension indicates an adequate and reliable supply (Costantini et al. 2007; Oh, Pang, and Chua 2010). Therefore, this study concludes that equitable access to electricity for all income groups in rural areas of Uttar Pradesh at a reasonable price can improve energy security. Otherwise, low affordability of electricity for rural consumers in Uttar Pradesh may result in decreasing accessibility and, therefore, the state's inability to meet the energy needs in the form of electricity (Sarangi et al. 2019). The analysis indicates that rural households belonging to low-income groups (i.e., below Rs5,000 per year) would not be able to afford a minimum level of electricity consumption in the absence of subsidies. Hence, there is a need to subsidize the consumption of this group of consumers.

### 6.2 Implications of Increasing Affordability and Accessibility for Economic Growth

Increasing the affordability and accessibility of electricity will increase the energy consumption in the state's economy on both the supply and the demand side. Because of the regional spillover effects of the electricity supply, there will be an increase in the sales of businesses, regional production, and real estate price (Taghizadeh-Hesary and Yoshino 2018; Yoshino, Taghizadeh-Hesary, and Nakahigashi, 2019). Consequently, the GDP of Uttar Pradesh will increase, which in turn will contribute to the earnings of the Uttar Pradesh Government through different forms of tax, such as income tax, corporate profit tax, property tax, and so on. Hence, in the long run, the fiscal status of the Uttar Pradesh Government will improve (Wolde-Rufael 2006; Karanfil and Li 2015; Yoshino, Taghizadeh-Hesary, and Nakahigashi 2019). Although electricity accessibility has improved significantly in recent times, affordability remains a challenge for a substantial proportion of the rural Uttar Pradesh population. This may limit the wider socio-economic benefits that the population can expect from increased access to electricity.



### 6.3 Implications of Low Affordability and Inadequate Tariffs on Financial Sustainability

Despite the tariff reforms undertaken, the payment of fiscal subsidies to compensate the UPPCL for supplying electricity to subsidized consumer categories has continued to increase. There are several reasons for this anomaly, as we explain below. A certain amount of energy that the producer supplies to the distribution network are lost as heat losses in the network. These constitute technical losses, and they are usually in the range of 5% in a well-engineered network. There are also certain commercial losses due to billing errors, illegal electricity connections, and consumers' electricity theft. Another factor contributing to India's distribution losses is the large number of unmetered residential and agriculture consumers, whose consumption the supplier estimates based on certain norms that the UPERC has set. However, unmetered consumers' actual consumption is higher than their estimated consumption, and the difference contributes to the distribution losses. The UPERC allows distribution losses (i.e., technical and commercial losses) of 12% in estimating the electricity purchase quantity. However, estimations have indicated that the actual distribution losses in the UPPCL network were 18% in FY2019, and this requires the UPPCL to purchase a larger quantity of electricity than the UPERC allows (UPERC 2019).

The UPPCL can collect only about 77% of the revenue that it bills to consumers due to the lack of payment discipline (i.e., agricultural consumers as well as certain government institutions) and affordability (i.e., poor residential consumers) among certain consumer categories. The UPERC assumes 98% bill collection as it calculates the ARR based on recognizing 100% of billed revenues as revenues and considering 2% of recognized revenues as provisioning for uncollectable receivables. The aggregate technical and commercial losses (ATCs), which are a key performance indicator in the Indian electricity sector, capture the low collection efficiency. The ATC losses combine the distribution losses and the collection efficiency,<sup>4</sup> and 36.8% ATC losses imply that the UPPCL collects revenues for 63.2% of the electricity that it has purchased. Table 10 summarizes the performance in terms of these key performance indicators (UPERC 2019).

**Table 10: Key Commercial Indicators of Uttar Pradesh Power Corporation Limited**

Year	Distribution Losses (%)	Collection Efficiency (%)	ATC Losses (%)	Account Receivables (Rs Billion)
FY 2015–16	22.6%	74.2%	42.6%	347.5
FY 2016–17	21.6%	73.0%	42.8%	458.9
FY 2017–18	21.3%	77.4%	39.1%	569.7
FY 2018–19	18.2%	77.2%	36.8%	682.7

Source: UPERC (2019).

Although the low collection efficiency does not affect the revenues or accounting profitability (i.e., the financial statements recognize the billed amount as revenues), it has a significant impact on the cash flows. The balance sheet reflects uncollected billed revenues as account receivables. Short-term loans finance the resultant cash flow deficit, and the UPERC does not consider the interest on these loans as an eligible expense

<sup>4</sup> ATC losses = 1 – collection efficiency × (1 – distribution losses).

that it must recover from consumers as it does not intend it for new asset creation and it is beyond the usual working capital requirement norms that the UPERC has set.

The actual amount of revenue subsidies that the government pays for supplying electricity below the cost of supply to subsidized consumer categories is less than the subsidy amount that the UPERC has approved. Short-term loans have funded the resulting gap, and the government does not consider the interest on these short-term loans as an eligible expense. The table below shows a comparison of the subsidies approved and subsidies received. The subsidy requirement is likely to increase by Rs30 billion because of the additional 8 million household connections made under the SAUBHAGYA scheme (Table 11). The government may not have the fiscal space to increase the subsidy payments to the UPPCL in the absence of a tariff increase for rural residential consumers.

**Table 11: Comparison of Uttar Pradesh Power Corporation Limited's Subsidies Approved and Subsidies Received**

Year	Subsidy Approved Rs. Billion	Subsidy Received Rs. Billion
FY 2016–17	125	67
FY 2017–18	95	70
FY 2018–19	122	112

Source: UPERC (2019).

## 7. CONCLUSIONS AND POLICY RECOMMENDATIONS

The results of our analysis substantiate the idea that enhancing the residential power service supply in emerging economies, particularly India, needs pro-active and efficient policies that complement electricity tariff reforms. These policies could include both supply-side interventions, such as reducing the electricity service cost, and demand-side instruments targeting larger consumers who may have higher WTP for a reliable electricity supply.

Although the Government of India has achieved the objective of near-universal household electrification, ensuring financial and fiscal sustainability of the electricity supply to rural areas in Northern India, where a significant proportion of the population has a monthly household income of less than Rs5,000, it remains a significant challenge. The prevailing tariff regime relies on sound principles of public utility regulation, and it allows electric utilities to levy a tariff that is adequate to achieve full cost recovery. If the government decides to provide specific categories of consumers with electricity below the cost recovery tariff, then it has to provide a direct subsidy to the electricity utility. However, the level of fiscal subsidies necessary to achieve full cost recovery under the prevailing level of affordability for poor consumers is not sustainable. Hence, this requires an innovative approach to limit the level of fiscal subsidies to a sustainable level.

To achieve these objectives, several initiatives are possible. First, utilities should convert all residential consumers to metered connections as early as possible by expediting the ongoing meterization program. This would minimize unmetered consumers' overconsumption and encourage energy conservation. Second, publicity and awareness campaigns should educate consumers on energy conservation in households and promote the sale of energy-efficient appliances for household applications, and the government may even offer subsidies until they achieve market acceptance. Third, suppliers should regularize the issuance of electricity bills and ensure the issuance of a

monthly bill every 30 days. Fourth, electricity companies should reduce the time and hassle involved in bill payment by appointing village/community-based collection agents and encourage more frequent bill payments to match the income patterns of village residents. They should also promote online and mobile payment options among the younger generation of consumers. Finally, the utilities should identify the consumers who regularly find it difficult to make timely bill payments. They should convert these consumers to pre-paid connections, meaning that the consumers need to make a payment to activate the connection, and once they have exhausted the payment, they have to make an additional payment. If the consumers cannot make a minimum payment of, say, Rs200 to have the minimum level of consumption and if they fall into the classification of a household below the poverty line (BPL), then the government can provide a specific cash subsidy of Rs200 per month for such consumers, providing them with a prepaid card that they can use to activate the prepaid meter.

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