A WORLD BANK STUDY

Power for All

ELECTRICITY ACCESS CHALLENGE IN INDIA

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Foreword

Today India's rural electrification program has reached a crossroad. By late 2012, the national electricity grid had been extended to more than 90 percent of rural villages. Yet, the policies and institutions that contributed to this impressive achievement are now constraining efforts to connect the 311 million people who remain without electric power—the last mile of the electricity grid. Of these, more than 100 million currently are beyond reach of the grid and could be reached using decentralized household or village systems. The other 200 million live in villages that already have electricity. Ironically, many of these potential consumers are choosing not to adopt a supply even though the draw of having electricity to take advantage of modern lighting and labor-saving devices is quite strong.

This book examines the main barriers to electricity adoption in rural India and offers lessons from successful state programs and international experience that point the way toward closing India's electricity access gap. The study draws on data collected from several annual rounds of India's National Sample Survey conducted during 2000–10 and the 2005 Human Development Survey. The research finds that the state utilities responsible for operating the network do not receive enough revenue from rural consumers to provide reliable service. Unreliable supply, in turn, discourages poorer households from spending scant income on intermittent service, further eroding the customer base and revenue flow. In villages with electricity, the extent of power outages and household adoption rates are linked. In addition, the institutional organization of rural electrification is unwieldy, with often overlapping responsibilities.

India must confront the reality that power reliability has become a major problem. The goal of extending electricity to the country's poorest rural customers has overshadowed the need to provide reliable, quality service to all households with electricity. The current grid program provides capital for new investments, but has overlooked policies that create supply shortages for the new households adopting electricity. Past investments in rural infrastructure are generating little revenue, infrastructure for providing electricity to village lines is underfinanced and unreliable, and the revenue stream from rural households is insufficient to secure a financially sustainable distribution system. The difficulty of pricing electricity appropriately while ensuring household affordability exacerbates these issues. Many states within India have achieved near universal service following well-established utility practices. But service reliability remains a problem throughout the country.

India can achieve its goal of universal electrification by 2030. The required financial investment is quite affordable, estimated at $2.4–3 billion annually. Success depends on complementing these investments with innovative solutions and policies aligned with global principles that are followed by developing countries and that have reached even their poorest and most remote populations. For example, India would benefit from a central institution with responsibilities that extends to include providing higher-quality service, charging consumers and providers a fair price, taking a customer-service focus, involving rural communities in the process of electrification, and customizing systems and technical standards to meet low levels of rural demand. One caveat is that the best international practices are mutually reinforcing and must be implemented together to achieve positive results. As India transitions to the final phase of its rural electrification program, the key challenge will be balancing access for all of its citizens with a stronger focus on providing higher-quality service.

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Abbreviations

APDRP	Accelerated Power Development and Reforms Program
APL	above poverty line
AREP	Accelerated Rural Electrification Program
ARR	Annual Revenue Requirement
BDS	Business Development Services
BPL	below poverty line
CPSU	Central Public Sector Utility
DDG	Decentralized Distributed Generation
GDP	gross domestic product
GW	gigawatt
HT	high tension
IEA	International Energy Agency
IREDA	Indian Renewable Energy Development Agency
JVVNL	Jaipur Vidyut Vitran Nigam Limited
kg	kilogram
klm-hr	kilolumen-hour
kV	kilovolt
kWh	kilowatt hour
LT	low tension
MNRE	Ministry of New and Renewable Energy
MOP	Ministry of Power
NGO	nongovernmental organization
NSSO	National Sample Survey Organization
PIA	Project Implementing Agency
PMGY	Pradhan Mantri Gramodaya Yojana
PV	photovoltaics
REC	Rural Electrification Corporation
REST	Rural Electricity Supply Technology
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana

RVE	Remote Village Electrification
SERC	State Electricity Regulatory Commission
SHG	self-help group
SHS	solar home system
T&D	transmission and distribution
TPIA	Third-Party Inspection Agency
W	watt

Currency Equivalents

All amounts are in Indian rupees unless otherwise indicated. All dollar amounts are in U.S. dollars. Indian rupees are converted to dollar amounts using the year-specific exchange rates taken from the *World Development Indicators*.

Year ranges with a slash (such as 2003/04) indicate fiscal years.

Executive Summary

India has been one of the world's leading developing countries in providing electricity to both rural and urban populations. The country's rural energy policies and institutions have contributed greatly to reducing globally the number of people who remain without electricity access. By late 2012, the national electricity grid had reached 92 percent of India's rural villages, that is, about 880 million people. Yet, owing mainly to its large population, India still has by far the world's largest number of households without electricity. About 311 million people still live without electricity, and they mostly reside in poor rural areas. Among these, 200 million live in villages that already have electricity. Less than half of all households in the poorest income group have electricity. Even among households that have electric service, hundreds of millions lack reliable supply, experiencing power cuts almost daily.

Achieving universal access to electricity by 2030 is not financially prohibitive for India. The challenge of providing electricity for all is achievable, ensuring that India joins such countries as China and Brazil in reaching out to even its most remote populations. The estimated annual investments necessary to reach universal access are in the range of Rs. 108 billion ($2.4 billion) to Rs. 139 billion ($3 billion). Considering that the country already spends about Rs. 45 billion ($1 billion) a year on new electricity lines through the current government program, the additional investments needed to achieve universal access by 2030 are quite reasonable. Investments are not the only hurdle to providing electricity to those presently without service. Policies will need to be aligned with the principles followed in other successful international programs.

The potential benefits of electrification for those without service are quite high. The benefits of lighting alone would approximately equal the investments necessary to extend electricity for all. When households that adopt electricity switch from kerosene lamps to electric light bulbs, they experience an enormous price drop for lighting energy and can have more light for a range of household activities, including reading, studying, cooking, and socializing. Households with electricity consume more than 100 times as much light as households with kerosene for about the same amount of money. The potential value of the additional lighting can be as large as 11.5 percent of a typical household's monthly budget. If universal access is achieved by 2030, the cumulative benefit for improved lighting alone would equal about Rs. 3.8 trillion ($69 billion) or Rs. 190 billion ($3.4 billion) in annual benefits. This is greater than the cost of providing electricity service, and does not even include such benefits as improved communications, household comfort, food preservation, and income from productive activities. With electric lighting, households can generate more income, and children can have better educational outcomes and income-earning potential. Without quality energy services, households often face entrenched poverty, poor delivery of social services, and limited opportunities for women and girls.

Status of Electrification Progress: Access and Reliability

Despite progress, India's population without electricity is still both large and poor. Of the 311 million people without electricity, about 93 percent live in rural areas and 40 percent are in the poorest income group. Among the 289 million rural residents without access, 70 percent are in the lowest 40 percent income groups. Among the wealthiest income group, only about 4 percent or some 10 million people lack access, compared to 53 percent or 125 million in the poorest income group. Just five states account for more than four-fifths of the people without electricity access. Bihar has the lowest overall access rate, at 25 percent, followed by Uttar Pradesh at 43 percent, Orissa at 56 percent, West Bengal at 59 percent, and Rajasthan at 77 percent. By contrast, 13 states have successfully provided electricity to more than 90 percent of their poorest populations.

Connecting poor households would not require huge additional investments in generation. For households with electricity access, average monthly power consumption for urban and rural areas is relatively low, at about 76 kilowatt-hour. Rural households consume only 54 kilowatt-hour per month on average—about half that of the average urban household. About 16 percent of all connected households consume less than 25 kilowatt-hour per month, equivalent to powering four light bulbs and a television set for a few hours a day. Households in the wealthiest quintile consume three times more electricity as those in the poorest quintile. Across states, average household power consumption ranges from a low of 25 kilowatt-hour to a high of about 181 kilowatt-hour in Delhi, where nearly three-fifths of households consume more than 100 kilowatt-hour per month. Thus, the investments necessary can be downscaled to meet the low electricity demand of the new households provided with electricity.

Poor power reliability curtails the electricity benefits. Most rural households that adopt electricity experience costly power outages. Only about 7 percent of rural households with electricity report no power outages, while 18 percent report outages of up to four hours a day. About one-fifth experience intermittent power supply throughout most of the day even though electricity lines run to their homes. Bihar and Uttar Pradesh—the two states that lag farthest behind in terms of both village coverage and household adoption—face the highest average daily outages. About 70 percent of grid-connected households use kerosene as a backup lighting source. In addition to the required minimum outlay on electricity service, these households must also spend an average of Rs. 26 ($0.6) per month on kerosene lighting, equivalent to purchasing 10 kilowatt-hour of electricity. The substantially higher amounts they pay to meet their monthly lighting needs also represent lost revenue for the state utility companies.

Poor power reliability limits the adoption of electricity. The extent of power outages and the rate of household adoption in villages with electricity are linked. Households living in villages with unreliable electricity supply probably question whether they should pay minimum monthly charges for a service that comes on and off during the evening hours, when electricity is used the most often. For example, in communities with daily service outages of 20 hours or more, the household adoption rate is just 38 percent, compared to more than 80 percent for those with few or no outages. After controlling for such factors as family size, education, and electricity price, raising the availability of electricity by just one hour per day increases the probability of household adoption by nearly 2 percent. Thus, providing both access and service reliability are keys to increasing India's electricity adoption rate.

For most without electricity, paying for new electric service is quite affordable. About 90 percent of rural consumers and even 82 percent of those in the poorest income quintile can afford to pay Rs. 90 ($2.0) a month for service—about the same amount of money poor households in India typically would pay for electricity. It is also about 5 percent of a poor household's budget, so this amount would be quite affordable. In addition, at an average tariff of about Rs. 3 ($0.07) per kilowatt-hour, Rs. 90 ($2.0) will buy 30 kilowatt-hour, which is consistent with the government's vision of ensuring minimum household consumption of 1 kilowatt-hour a day.

Historical Progress in Providing Energy Access

The Government of India is committed to achieving universal electricity coverage, recognizing the many benefits that electrification affords households and the constraints on those that lack access. India's government has emphasized electrification in its national policies, having allocated substantial resources, particularly in the past decade, to increasing electricity access. Given India's large population, efforts to achieve universal access nationally will contribute greatly to achieving the United Nations' Sustainable Energy for All initiative, whose target is universal access to modern energy services by 2030.

Historically, India's rural electrification policies have shifted from line extension to villages to agricultural production, rural development, and finally access by the poor. Prior to the late 1960s, India's growth in rural electrification was extremely slow. At the time of the country's independence in 1947, only 1,500 villages had electricity. By the late 1950s, coverage had been extended to 18,689 villages, but only 350 of the originally targeted 856 towns had been reached. In direct response to severe droughts and food shortages suffered in the early 1960s, the government began to emphasize rural electrification's importance for improving productive uses, including irrigation and commercial development. From the late 1960s through the 1970s, government policies, including low electricity tariffs for agriculture, encouraged farmers to adopt electric pump sets and irrigation practices. A major institutional push occurred in 1969 with the creation of the Rural Electrification Corporation (REC). On recommendation of the All India Rural Credit Review Committee of 1966–69, the REC was established as a financing institution to promote investment in rural electrification, with a focus on agricultural production. In the late 1970s, the government widened its attention toward rural development and household access. In the late 1990s, rural electrification began to be viewed more as a prime mover of rural development. Since 2000, growth in grid and off-grid household access has accelerated, particularly in poorer rural areas.

At the national level, India's electricity sector is governed by the Ministry of Power (MOP) and the Ministry of New and Renewable Energy (MNRE). Established in 1992, the MOP is responsible for developing the electricity sector and implementing the landmark Electricity Act of 2003. The MNRE is in charge of developing new and alternative energy technologies and promoting renewable energy. With the 2005 launching of the flagship rural electrification program, Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), progress toward achieving electricity access and supply goals has gained momentum. RGGVY's main objectives are to electrify all village and habitations with more than 100 people, install small generators and distribution networks where grid extension is not considered cost-effective, and provide free electricity connections to households below the poverty line. Complementing RGGVY is the MNRE-implemented Remote Village Electrification (RVE) program.

During the last decade (2000–10), the RGGVY and MNRE programs generally have been effective in expanding access to electricity. India's electrification rate reached 74 percent by the end of the decade, an increase of 15 percent from 2000. Seventy percent of the newly electrified population resided in rural areas, reflecting the country's focus on rural electrification, as well as the relative saturation already achieved in urban areas. About 65 percent of the access increment kept pace with population growth, meaning that the remaining 35 percent or 99 million electricity users were added over and above the population increase. Across states, growth in electricity access varied substantially relative to population growth. In Andhra Pradesh and West Bengal, growth in electricity adoption outpaced population growth by more than 10 million people. However, in the larger states of Uttar Pradesh and Bihar, electricity adoption failed to even keep up with population growth.

The RGGVY program has succeeded in expanding electricity adoption, but policy reform has failed to keep pace. Today the sustainability of the RGGVY program is challenged by the little revenue being realized from past investments in rural infrastructure. Over the longer term, the program faces two challenges. The first is that the infrastructure for providing electricity to the village lines is both underfinanced and unreliable. The second is that the revenue stream from rural households is insufficient to secure a financially sustainable electricity distribution system. These issues are exacerbated by the difficulty of appropriately pricing electricity while ensuring household affordability. The program focuses on providing capital for new investments, but does nothing about the policies that create supply shortages for the new households adopting electricity.

Reversing the problems of India's rural electrification program will require innovation and policy reforms. For the future, solutions are needed to expand electricity access in financially responsible ways that encourage investment in the operation and maintenance of rural systems. With the passage of time, there has resulted a complex web of various well-meaning policies and institutions that now are constraining efforts to connect the remaining populations without electricity—the last mile of the electricity grids. Solutions to reach these households might include extension of the existing electricity grid, guaranteed electricity reliability, new private or cooperative distribution companies, or off-grid renewable systems. Achieving the right balance between these and other options is a challenge that will last well into the future.

Policy Recommendations for Moving Forward

Many international programs have dealt with the same challenges now facing India in its final phase of expanding electricity access to its poorest and most remote populations. Experiences in such diverse countries as China, Mexico, and Chile show that success in rural electrification can be achieved in many ways. Mexico has a large national electricity company that gets annual operating subsidies to lower electricity prices for consumers. Today, China has mostly public electricity companies that generate and transmit electricity to about 1,000 county distribution utilities. Chile has private, vertically integrated electricity companies with defined service territories that apply to a government program for grants that can be used to extend electricity access. Positive financial rates of return for the companies and also positive economic rates of returns for the country are required for all communities in the grant applications. Despite this diversity of approaches, the countries all follow a similar set of principles to implement their successful rural electrification programs. These principles range from having sustained government commitment over a long period of time to having pricing or subsidy policies that allow electricity companies to recover costs and reinvest in maintaining lines and equipment, enabling them to provide a high quality of service. India has a long history of government commitment, but also has a poor record of providing local electricity companies the right incentives to provide rural customers high-quality service. The best international practices point the way forward to achieve universal electricity access in India. But they cannot be adopted in a piecemeal fashion because they reinforce each other in ways that will lead to positive results in providing electricity for all.

India would benefit from a more focused institutional approach that integrates grid and off-grid efforts in rural areas. Today, the rural electrification puzzle is broken up into various pieces: the MOP, MNRE, REC, and State Electricity

Boards. A more integrated approach between the MOP and MNRE is needed to coordinate grid and off-grid schemes. One agency needs to be in charge to coordinate efforts guided by a transparent, long-term vision. At a minimum, the REC should consider ways to transfer knowledge management practices from the Central Public Sector Utilities (CPSUs) to the state utilities. The building and transferring of lines to the state electricity companies is financially easier, but fraught with ownership problems for the states. A close working relationship between the CPSUs and the state utilities would contribute to successful RGGVY program implementation through better project management practices, with enforceable oversight from a central agency responsible for rural electrification. In addition, concessions based on minimum necessary subsidies to attract the private sector operating distribution franchisees in rural areas might be considered. Currently, new franchises are hampered by having to adhere to the same rules as the state electricity companies. India needs to harness the potential of the utilities, private sector, regulators, communities, and financial institutions to create preconditions so that each of them can individually benefit from and contribute to the universal access goal.

Planning and load development require monitoring the quality of service and connection information, encouraging productive uses to increase demand, and supporting local generation and supply. Currently, distribution companies tend to underfund investment in rural electrification, perceiving that it generates insufficient revenue; this, in turn, leads to unreliable supply. Thus, subsidies or incentives to build lines need to ensure appropriate investments are in place to maintain them. Also, state distribution companies need to systematically keep track of regional power supply reliability and report outages on a regular basis to the state regulator and government. Load development can be improved through bundling complementary services that encourage productive electricity uses. For communities beyond the grid, solar home systems, local generation, energy-efficient lights, and other new technologies are available at reasonable cost. Grid and off-grid options are not mutually exclusive and can be implemented in parallel.

To improve utility cost recovery, rural customers need to pay monthly bills based on tariff levels that provide the utilities incentives to service them. Utility officials have indicated that the revenue from supplying new below poverty line (BPL) consumers in some instances is too low to cover even bill collection. Most of the service provided under the RGGVY scheme involves flat-rate tariffs, which result in losses for the utilities. Lessons from innovative metering and collection systems developed in many countries might be implemented to reduce the utilities' commercial risks and give rural households more control over their consumption. Increasing access for the poor is likely to require a relatively minimal increment of additional generation capacity. Thus, it is essential that this capacity be available and reliable to serve newly connected rural consumers. The goal is for rural areas to eventually become a source of profit, rather than financial loss, for the electricity companies. This may not materialize in the short term; however, it should be clear that rural areas will contribute to, not take away from, the long-term financial health of the electricity companies. Ironically, increasing the prices that rural customers pay for electricity may actually provide the incentive necessary for companies to provide higher-quality service. This, in turn, will result in more, rather than less, household and productive use of electricity. This is the virtuous cycle that has led other countries to have successful rural electrification programs.

Barriers to adoption can be lowered by improving maintenance of rural distribution lines and providing above poverty line (APL) households free connections to improve load and financial return. In India, ensuring a reliable electricity supply is critical to improving household adoption rates in villages with grid service. Improving rural distribution systems must be assigned a higher priority, as better reliability will lead to higher numbers of new connections. This will require a large financial investment for India. Since most of the country's rural households without electricity are poor, having an artificial poverty line that gives priority to those at the very bottom of society, however noble, would only serve to complicate the process of implementing universal electricity access. APL households, which are excluded from the free connections received by BPL households, may not be able to afford the up-front costs of adopting electricity service. A caveat is that free connections, combined with low electricity prices, would be quite problematic for the long-term financial viability of rural service delivery. A review of connection fees, reconnection charges, minimum charges, and service reliability would be a priority to understand why many of the poorest households in villages with power are choosing not to adopt electricity.

India's electricity sector needs to focus more on community involvement and service orientation. International experience confirms that involving local communities from a program's outset results in multiple benefits—better designed programs, gaining of local support, mobilization of cash and in-kind contributions, and increased local ownership—that contribute to operational sustainability. Pathways need to be developed to improve interaction between customers and the electricity companies. Local units within companies could be created to handle and develop solutions for rural service problems. In most developed countries, for example, community-outreach liaison officers are a standard feature. Overall, better trust is needed between the utilities and their customers. Improving relationships might involve community representatives that can report problems or request new service for customers. Today's low level of local participation in the RGGVY process is putting the future sustainability of rural service delivery at risk. States that have already begun involving local self-help government entities, women's self-help groups, and other community-based organizations offer useful lessons. Most of the 200 million people in villages with electricity that have not adopted it can afford to pay for electricity. Given the already high sunk capital costs in reaching communities, having high percentages of people not adopting electricity is a significant financial loss for the electricity companies. Improvements in service reliability, application procedures, and local community involvement will help companies reach customers near power lines that still have not adopted electricity. These customers can be considered the "low-hanging fruit" for making rural electrification a more financially sound program for the state electricity companies.

India has major opportunities to redesign its rural electricity infrastructure to match design standards to actual demand and ensure capital construction for new lines does not overshadow operating costs. Lessons from other countries indicate that using expensive technical designs to extend electricity in rural areas can cost up to 30 percent more than those more appropriate for rural levels of demand. Where the main expected household uses of electricity are lighting and running small appliances, the rural distribution system can be designed for such low loads. Rural customers often consume no more than 30–50 kilowatt-hour per month. At the same time, the electricity industry should not lose sight of the significant levels of lost revenue from the hundreds of millions of customers that experience outages, as well as those who choose not to connect to the grid because of poor service reliability. State regulators need to effectively monitor and encourage higher service standards, but this does not necessarily imply high-cost electricity systems. One possible way to promote better customer service may be to develop a system of subsidy payments linked to reliability with clearly defined quality parameters for electricity customers.

India can achieve universal electrification by 2030. Success of the access expansion program will fall to the state electricity companies, but they will need support. At present, they are provided incentives to string lines through capital and other subsidies, or other contractors are building the lines and turning them over to the state electricity companies. Thus, these companies have little incentive to serve those living along the lines due to low electricity prices and/or lack of subsidies for operation and maintenance. The results have been poor reliability and loss of benefits for those with electricity service, and a disincentive for those without electricity to adopt a connection.

Though the problems have been politically hard to overcome, the solution is not complicated. It can be accomplished by having a central institution responsible for more than just providing subsidies for lines. It should also be responsible for providing higher-quality service, charging a fair price to consumers and providers alike, paying more attention to customer service, involving rural communities more in the process of electrification, and developing systems and technical standards more appropriate for rural levels of demand. As India enters a new age of modernization, it is important that electricity not only be provided to all of its citizens; the service offered should also be closer to the levels found in the rest of the developed world.

CHAPTER 1

Introduction

Abstract

India has led the developing world in addressing rural energy problems. By late 2012, the national electricity grid had reached 92 percent of India's rural villages, about 880 million people. In more remote areas and those with geographically difficult terrain, where grid extension is not economically viable, off-grid solutions using renewable-energy sources for electricity generation and distribution have been promoted. The positive results of the country's rural energy policies and institutions have contributed greatly to reducing the number of people globally who remain without electricity access. Yet, owing mainly to its large population, India has by far the world's largest number of households without electricity. More than one-quarter of its population or about 311 million people—the vast majority of whom live in poorer rural areas—still lack an electricity connection; less than half of all households in the poorest income group have electricity. Among households with electricity service, hundreds of millions lack reliable power supply.

Commitment to Universal Access

The Government of India recognizes the many benefits that electrification affords households and the constraints on those that lack access to quality energy services. Without electricity, households are entrenched in poverty, suffer poor delivery of social services, and have limited opportunities for women and girls. In the last decade, the government has increased the emphasis of national policies on electricity access, and has backed up this commitment with substantial resources. India's national policy vision of universal electricity coverage also is consistent with achieving the United Nations' Sustainable Energy for All initiative, whose target is universal access to modern energy services by 2030.

Efforts to achieve universal access nationally will require extending coverage to 573 million more people—the 311 million without electricity today, along with 263 million that will be added as a result of population growth. By 2030, 218 million urban residents will require new electricity service connections, compared to 355 million in rural areas.[1] Thus, the future electrification challenge will be balancing the needs of a growing urban population with the backlog of demand in rural areas. Both grid and off-grid solutions will be needed to achieve the universal access goal. The grid system already reaches more than 90 percent of India's villages, so the remaining 10 percent will be serviced by a combination of grid expansion, mini-grids, and solar home systems (SHSs). In urban areas, where all new connections will be grid based, the challenge will be how to service poor residents in densely populated slums and other disadvantaged communities.

Achieving universal access to electricity will not be financially prohibitive for India, and the potential benefits are enormous. The annual investment over a 20-year period (2010–30) is estimated at \$2.4–3 billion (Rs. 108–139 billion).[2] India already spends about \$1 billion (Rs. 45 billion) per year on new electricity lines through Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), its flagship rural electrification program, so this goal is quite achievable. For improved lighting alone, universal electricity access would generate cumulative consumer surplus benefits of \$69 billion (Rs. 3.8 trillion) or \$3.4 billion (Rs. 190 billion) annually. Many additional socioeconomic gains also would continue to accrue well beyond 2030.

Benefits of Electrification

The socioeconomic benefits of electrification are well established (Nieuwenhout, van de Rijt, and Wiggelinkhuizen 1998; Cabraal, Barnes, and Agarwal 2005; Asaduzzaman, Barnes, and Khandker 2009; Khandker, Barnes, and Samad 2013). Switching from the dim, polluting light provided by kerosene lamps and lanterns to higher-quality, less polluting electric lighting has the immediate effect of increasing children's evening study hours, which can improve their educational outcomes and longer-term income-earning potential (Barakat et al. 2002; Khandker, Barnes, and Samad 2012). The reduction in household air pollution from kerosene substitution also is linked to a decreased risk of respiratory disease and related illnesses, particularly among women and young children.

With electric lighting, household businesses can extend their hours of operation to generate more income, and farm households can switch from manual to electric tools and machinery to increase their productivity and profits. Family members, particularly women, will read, watch television, and listen to the radio, thus gaining valuable access to knowledge that can help with their decision-making power within the household. Additional benefits of electrification include a greater sense of public security and more time in the evenings for socialization and entertainment. The cumulative impact of all these benefits is an improved quality of life.

Study Goal and Organization of this Report

This study analyzes India's remarkable progress toward achieving universal access to electricity, particularly since 2000, and identifies the remaining challenges ahead.[3] Key supply-side and demand-side barriers to adoption, as well as program sustainability issues, are examined. The study also draws on lessons from international experience to formulate a set of recommendations for reaching universal access. The target audiences for the report are primarily central policy makers responsible for setting overarching electrification policies and state utilities and regulatory commissions that implement rural electrification projects and set electricity tariffs.

The report is structured as follows. Chapter 2 highlights the recent growth trend in electricity access, identifies population groups that remain without a supply, and estimates the benefits of rural electrification. Chapter 3 presents the main barriers to rural household adoption. Chapter 4 then outlines the history of India's rural electrification and institutional organization for grid and off-grid programs. Chapter 5 evaluates the access challenges under the current grid-based program and highlights successful state strategies that have overcome them. Finally, chapter 6 offers lessons from international experience for India to consider as it moves forward.

Notes

1. Details are available at http://esa.un.org/unup/.
2. Appendix A provides details.
3. The study draws from data collected from three selected annual rounds of the National Sample Survey conducted during 2000–10 and the 2005 India Human Development Survey, which included extensive questions on delivery of energy services (appendix B). It also draws on information from a background report prepared by PricewaterhouseCoopers. The report used a combination of detailed desk-based research on all states and a well-structured, systematically administered primary survey; this was supported and validated through targeted field visits and consultations with multiple stakeholders in 12 states representative of a wide array of access situations (Andhra Pradesh, Assam, Bihar, Gujarat, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, and West Bengal).

CHAPTER 2

Closing the Electricity Access Gap

Abstract

India has made dramatic strides toward providing all of its citizens access to electricity. Between 2000 and 2010, about 283 million people were connected—a much higher figure than the natural population increase. By 2010, the country's total population with electricity had reached 881 million. Despite this remarkable progress, 311 million people, mainly poorer rural households, remain without power. This chapter examines recent growth trends in electrification in urban and rural areas and across income groups, generally characterizes the population groups without electricity, and estimates some of the minimum benefits of electricity for households that gain access.

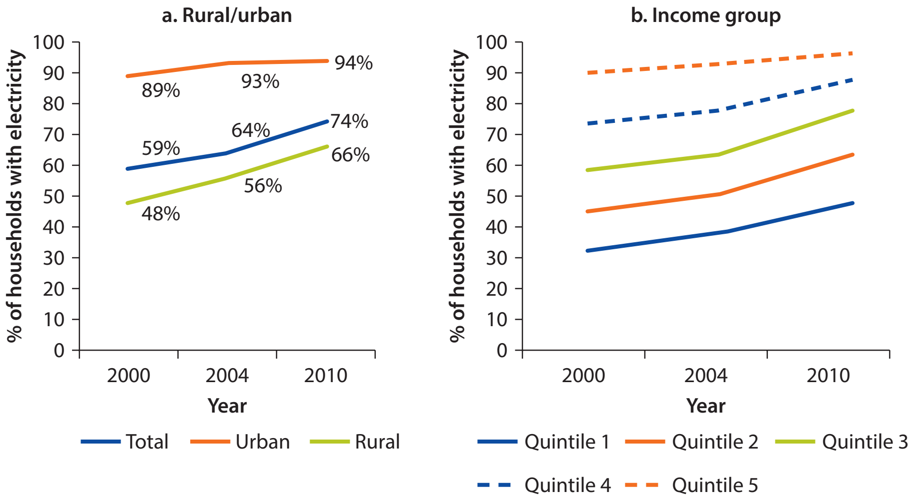
Recent Growth Trends

Most households that gained access to electricity between 2000 and 2010 resided in rural areas, reflecting India's focus on rural electrification and the fact that urban coverage was nearing saturation (figure 2.1a). Over that decade, rural access rates grew by 18 percentage points, 13 percentage points higher than for urban areas, where coverage had already reached 89 percent by 2000. Adoption rates for households in the poorest quintile grew by 15 percentage points, compared to only 6 percentage points for households in the wealthiest quintile, 90 percent of whom already had electricity in 2000 (figure 2.1b).

Rural and urban residents, respectively, accounted for about 70 percent and 30 percent of the access gains (figure 2.2a) during 2000–10, which were distributed rather evenly across income groups, with the three middle-income quintiles accounting for about two-thirds of those connected (figure 2.2b). Over the decade, the states of Bihar, West Bengal, and Andhra Pradesh had the most successful programs for providing electricity to those without service.

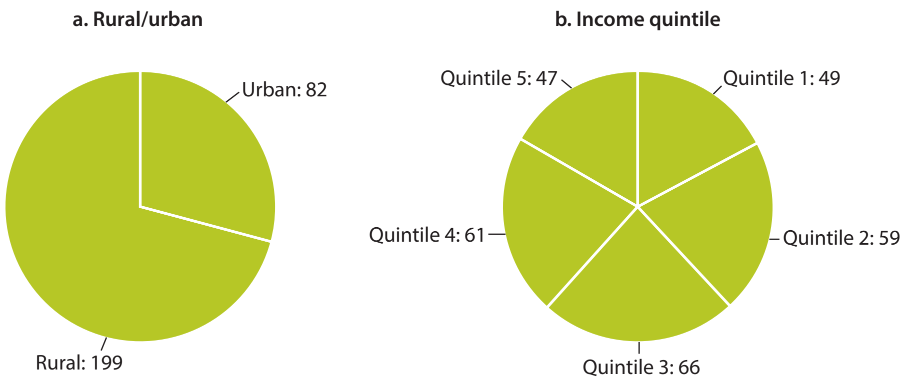
Population growth means that India has many newly established households that must be serviced by the electricity companies. Between 2000 and 2010, annual population growth was about 1.5 percent, while annual electricity

Figure 2.1 Comparative Growth in Household Electricity Access, 2000–10



Source: National Sample Survey 2000, 2004, 2010.

Figure 2.2 Millions of People Who Gained Electricity Access, 2000–10

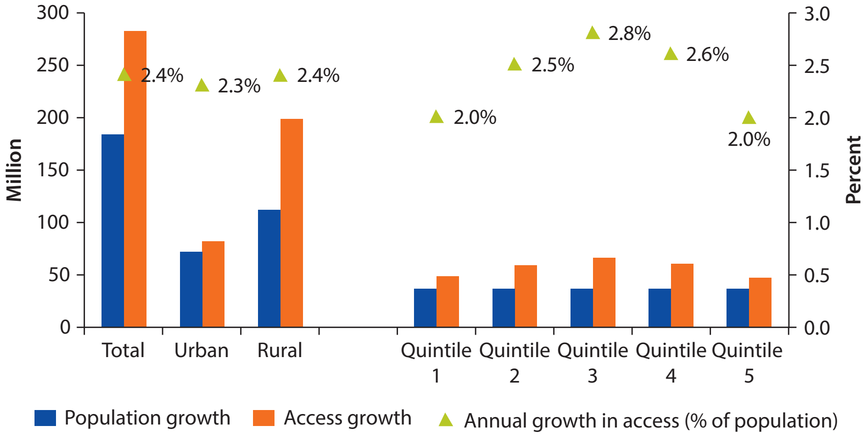


Source: National Sample Survey 2000, 2010.

adoption grew by 2.4 percent overall. This means that about 65 percent of the new electricity adoption simply kept pace with population growth, while the remaining 35 percent or 99 million electricity users were added over and beyond the population increase. Growth rates across rural and urban areas and income quintiles were similar, with middle-income groups having the highest reported growth rates (figure 2.3).

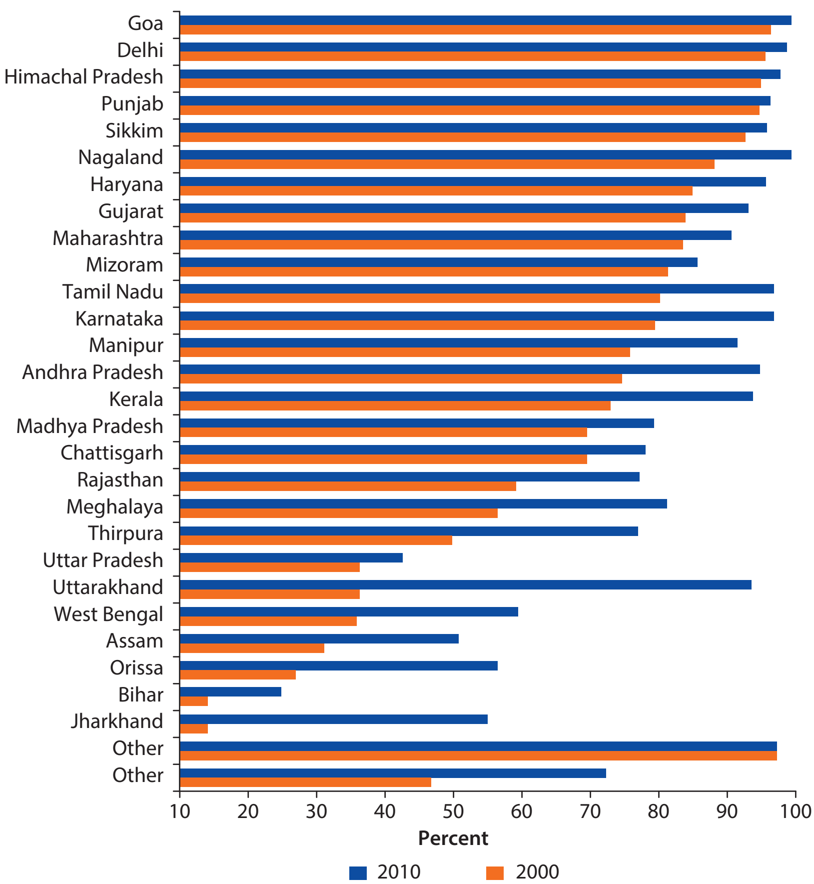
The states in India that have been the most successful at rural electrification also had small increases in the percentage of people that adopted new connections during 2000–10. By 2000, more than 90 percent of households in Goa, Delhi, Himachal Pradesh, and Punjab already had electricity. The two states with the highest rates of electricity adoption over the decade—Uttarakhand

Figure 2.3 Growth in Electricity Access, 2000–10



Source: National Sample Survey 2000, 2010.
Note: Percent annual growth rates by income level were 2.0 (quintile 1), 2.5 (quintile 2), 2.8 (quintile 3), 2.6 (quintile 4), and 2.0 (quintile 5).

Figure 2.4 Electricity Access Rates for Selected States, 2000 and 2010

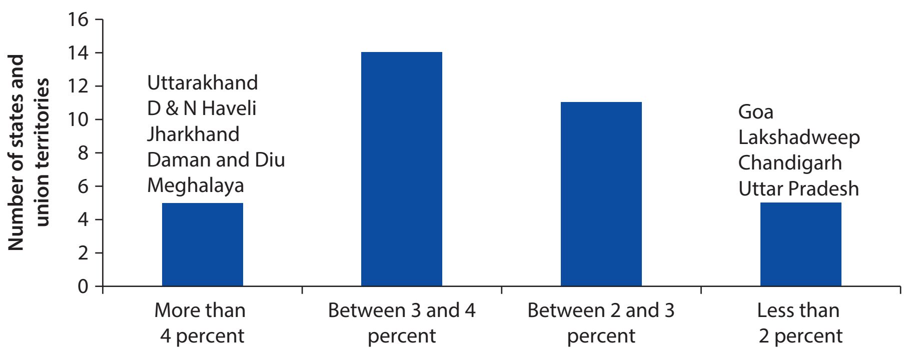


Source: National Sample Survey 2000, 2010.

and Jharkhand—started out with quite low electrification rates in 2000. States with adoption rates below 90 percent in 2000 that performed poorly over the decade include Chhattisgarh, Mizoram, and Uttar Pradesh, which had rate increases ranging from 4 to 10 percentage points (figure 2.4).

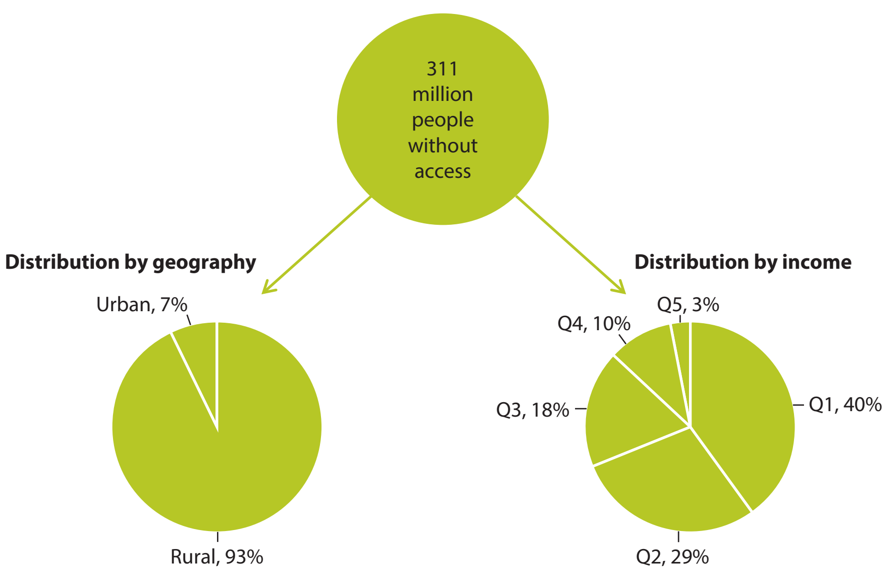
Over the decade, growth in electricity adoption varied substantially across states, especially when considered in relation to population growth. In the larger states of Uttar Pradesh and Bihar, access growth did not keep pace with population growth. Uttar Pradesh experienced its largest gains in the early part of the decade, but then failed to keep pace in the latter half. Andhra Pradesh and West Bengal recorded the largest absolute increases in population with electricity;

Figure 2.5 Electricity Access Growth across States and Union Territories, 2000–10



Source: National Sample Survey 2000, 2010.

Figure 2.6 Distribution of Nonelectrified Population



Source: National Sample Survey 2010.

access growth outpaced population growth by more than 10 million people. Uttarakhand grew at the fastest pace, at 6 percent annually, followed by Jharkhand at 4.3 percent. For most states, the populations with electricity grew by an average of 2–4 percent per year (figure 2.5).

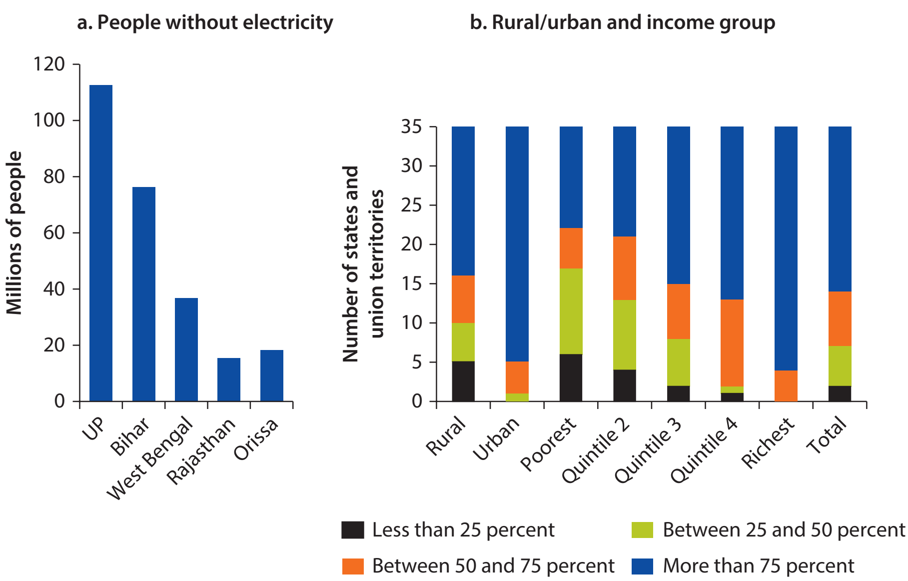
Current Profile of Electricity Deficit

The task remaining for India is to have a program that reaches out to those people that still lack electricity. Statistics from the National Sample Survey confirm that India's remaining 311 million people without electricity include the country's poorest people living in the most remote areas. About 93 percent of those without electricity reside in rural areas, and approximately 40 percent are in the poorest income quintile (figure 2.6). For the 289 million rural residents without access, 70 percent are at the bottom 40 percent of income groups. In contrast to these stark figures, only about 4 percent or some 10 million people in the wealthiest income group lack electricity.

Variations in Access Rates across States

Out of India's 35 states and union territories, just five states account for more than four-fifths of people without electricity access (figure 2.7a). Bihar has the lowest overall access rate, at 25 percent, followed by Uttar Pradesh at 43 percent, Orissa at 56 percent, West Bengal at 59 percent, and Rajasthan at 77 percent (figure 2.7a). For these five states, along with Assam, electricity access rates for the poorest income group are well below the 47 percent all-India average for the

Figure 2.7 Distribution of Access Rates in States and Union Territories, 2010



Source: National Sample Survey 2010.
Note: UP = Uttar Pradesh.

poorest households. Uttar Pradesh and Bihar alone account for half of the population without electricity in both the richest and poorest quintiles. At the opposite end of the spectrum, 13 states have provided electricity to more than 90 percent of even their poorest income groups.

The heterogeneity of access rates across states is greater for rural areas, compared to urban ones (figure 2.7b). Thirty states and union territories report urban access rates above 90 percent. Bihar exhibits the lowest urban access rate, at 70 percent. Five states have electrified less than half of their rural populations, with Bihar (19 percent) and Uttar Pradesh (32 percent) at the low end. Only 19 states report rural access rates above 90 percent.

Consumption Patterns across States

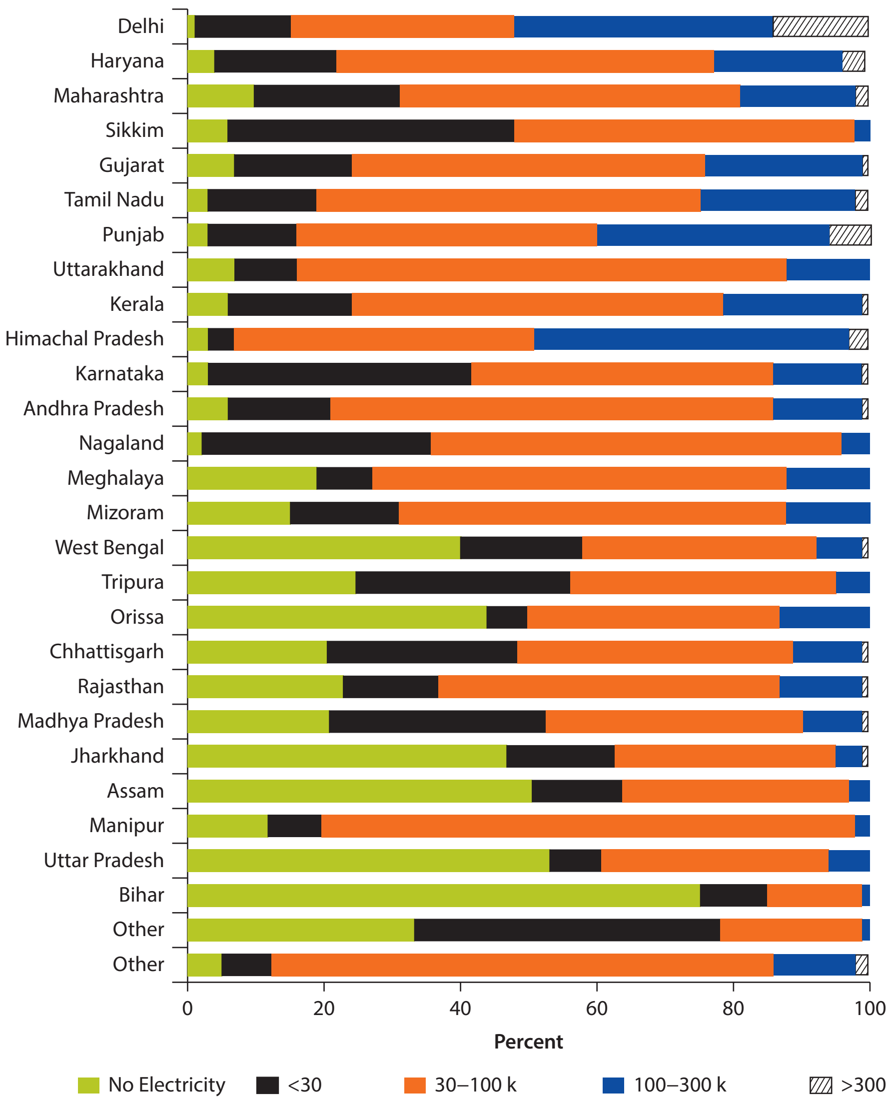
The level of household power consumption is relatively low, averaging 76 kilowatt-hour per month, but varies considerably across states and between rural and urban areas. Delhi has the highest at 180 kilowatt-hour (table C.3, appendix C). Since Delhi is mostly an urban conglomerate, it would be expected that households there would consume more electricity compared to states with high numbers of rural households. More than three-fifths of households in Delhi consume more than 100 kilowatt-hour per month (figure 2.8). By contrast, nearly four-fifths of households in Bihar consume no electricity, mostly because they have no electric connection. Even in Nagaland, where access rates are higher, 95 percent of households consume less than 100 kilowatt-hour per month. Overall, rural households consume an average of only 54 kilowatt-hour per month, about half as much as urban households (table C.3, appendix C). About 16 percent of all households with electricity consume less than 25 kilowatt-hour per month—equivalent to powering four light bulbs and a television set for a few hours a day.

The relationship between electricity access rates and average household power consumption is not straightforward. The union territories of Delhi and Chandigarh have high rates of electrification and also have the highest consumption rates. But some states at or near universal access have only modest levels of electricity use. For example, Tripura and Sikkim have universal access, but their consumption levels are similar to those of Bihar, which has the lowest consumption and access rates (figure 2.9). Thus, one must look to other factors, such as supply reliability and household income, to understand patterns of electricity consumption.

Determinants of Household Adoption

Many factors may be related to the percent or number of people without electricity. The states appear to play a major role, and the financial health and competence of the electricity companies also appear highly related. In addition, various household-level factors appear quite important in determining whether a household adopts electricity. These include the educational level of the household head and the household's primary income source. In households with

Figure 2.8 Distribution of Monthly Household Consumption for Selected States, 2010

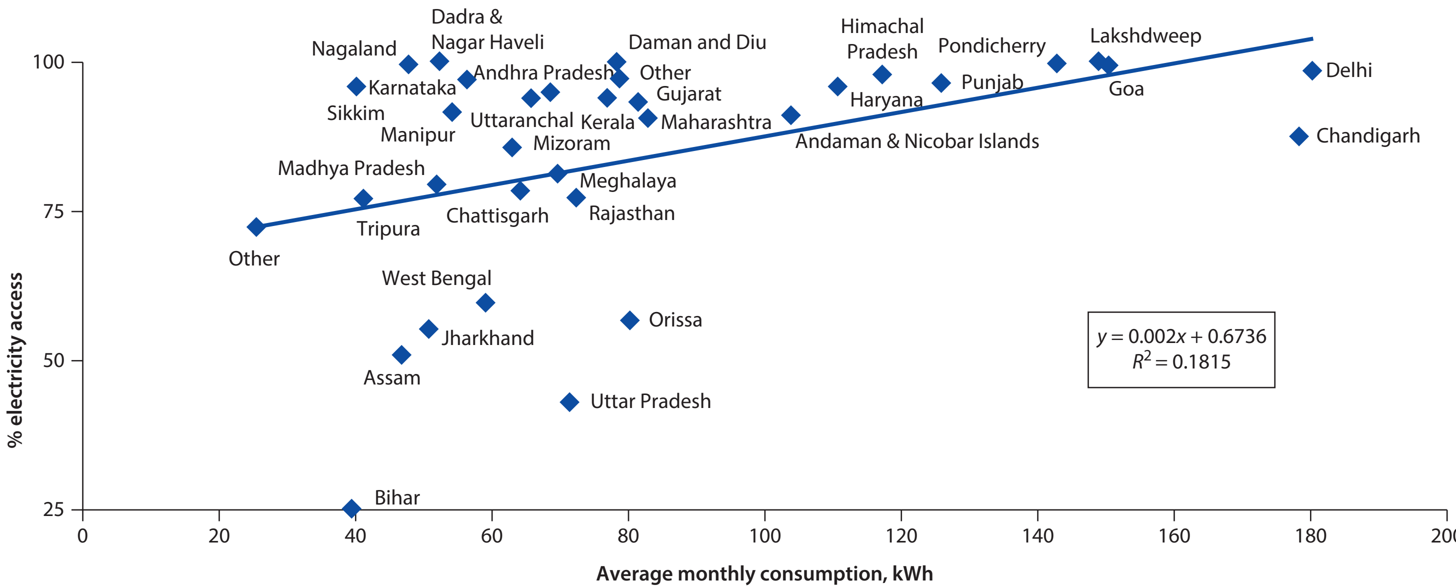


Source: National Sample Survey 2010.
Note: States are ordered by GDP per capita (2010 figures).

electricity, the literacy rates of household heads are 86 percent in urban areas and 66 percent in rural areas, compared to only 57 percent and 48 percent, respectively, in households without electricity.

Having a regular wage also makes it quite likely that a household adopts electricity. In urban areas, 40 percent of households with electricity are regular wage earners, compared to only 16 percent in households without electricity. This trend is followed closely by household expenditure, a proxy for household

Figure 2.9 Distribution of Household Consumption Levels among States, 2010



Source: National Sample Survey 2010.

income. In rural areas, the monthly expenditure of households without electricity (Rs. 781) is nearly one-third less than that of households with electricity (Rs. 1,209). No doubt, this means that income is an important factor in the decision to adopt electricity service. However, it should be cautioned that some of these patterns may be caused by the long-term benefits generated by adopting electricity. The next section considers some of the minimum benefits of having electricity, while the patterns of electricity adoption are examined more closely in chapter 3.

Estimated Benefits of Universal Access

When households gain access to electricity, they use it as their primary lighting source, replacing the dim, low-quality lighting provided by kerosene wick lamps or hurricane lanterns. Households with electricity spend somewhat more each month on electricity than households without electricity spend on kerosene (Rs. 66 [$1.5] versus Rs. 46 [$1]). But they spend substantially less per unit of lighting because of electric lighting's higher efficiency. Households with electricity get more than 100 times as much light as do households with kerosene for about the same amount of money. Thus, households that adopt electricity can realize substantial cost savings per unit of lighting (table 2.1).[1]

To estimate the benefit of adopting electricity, the study applied the consumer surplus method. Consumer surplus has long been used in economics to estimate the benefits of public projects (Marshall 1930; Varian 1978).[2] When households switch from kerosene to electricity, they experience an enormous price drop for lighting. Households with electricity pay only Rs. 0.2 per kilolumen-hour, compared to about Rs. 10 per kilolumen-hour paid by those who use kerosene. As a result of the lower per-unit price, households with electricity can enjoy the benefits of a substantially larger amount of lighting. Consumer surplus estimates the

Table 2.1 Household Cost Savings from Switching from Kerosene to Electric Lighting

Household type	*Without electricity*	*With electricity*
Lighting source	Kerosene	Grid electricity
Amount spent (Rs./month)	46	66
Quantity used per month	2.76 liters	28.4 kWh
Lighting energy received (klm-hrs./month)[a]	2.6 (wick lamp), 4.4 (hurricane lantern)	307.9 (40-W bulb), 348.5 (60-W bulb)
Cost per unit of lighting energy (Rs./klm-hr.)	17.7 (wick lamp), 10.5 (hurricane lantern)	0.21 (40-W bulb), 0.19 (60-W bulb)
Savings per unit of lighting energy (%)	—	98–99

Source: India Human Development Survey 2005.
Note: The exchange rate used is $1 = Rs. 44.1 (World Development Indicators figures for 2005).
a. Lighting energy is calculated by multiplying the quantity used by a conversion factor of the following values: 0.95 for kerosene wick lamp, 1.58 for kerosene hurricane lantern, 10.84 for 40-W incandescent bulb, and 12.27 for 60-W fluorescent bulb.

Table 2.2 Consumer Surplus for Switching from Kerosene to Electricity in Rural India

Switching type	*Consumer surplus (value of improved lighting) (Rs./month)*	*Consumer surplus as a share of income (%)*
From wick lamp to 40-W bulb	245	11.2
From wick lamp to 60-W bulb	252	11.5
From hurricane lantern to 40-W bulb	216	9.9
From hurricane lantern to 60-W bulb	223	10.2

Source: India Human Development Survey 2005.
Note: The sample is restricted to households that use kerosene or electricity for lighting only; the exchange rate used is $1 = Rs. 44.1 (World Development Indicators figures for 2005).

total potential savings that results from using such larger amounts of lighting at lower prices. The benefit called consumer surplus is derived from consumers' ability to make use of more lighting at a lower cost than kerosene or other alternative lighting sources.

For India, consumer surplus can be calculated for the four alternate possibilities for switching from kerosene to electric lighting. Moving from either a kerosene wick lamp or hurricane lantern to even a minimal substitute 40-W or 60-W bulb can generate substantial additional value for households. Among the four possibilities, switching from a kerosene wick lamp to a 60-W bulb results in the largest gain in consumer surplus (Rs. 252 [$5.7]), while switching from a hurricane lantern to a 40-W bulb yields the smallest gain (Rs. 216 [$4.9]) (table 2.2). Obviously, the benefits of improved lighting to the consumer household are much higher than the cost incurred. The potential value to consumer surplus can be as large as 11.5 percent of the monthly household budget.

Consumer surplus for the household can be extrapolated to the entire population without electricity. If universal access is achieved by 2030, the cumulative consumer surplus would equal about Rs. 3.8 trillion ($69 billion), assuming each household achieves Rs. 616 ($14) in consumer surplus upon connecting to electricity.[3] This translates to about Rs. 190 billion ($3.4 billion) in annual benefits resulting from switching from kerosene to electricity.[4] Importantly, this is the lower bound of the benefits of electricity. Other socioeconomic benefits accrue on top of this and are likely to continue well beyond 2030. Thus, this is a conservative estimate of the total benefits that achieving universal electricity access will have for households in India. If the right policies can be put in place to promote universal electricity access—those that do not deter electricity companies from providing service—the benefits of the program will be substantial and far reaching.

Summary Remarks

India's program to achieve universal electricity access has been quite successful overall, yet two key challenges remain. Many states now have only the final 5–10 percent of their populations without electricity, and only a handful have large nonelectrified populations. Even so, the numbers of people without electricity total the large figure of about 311 million. Of these, about 200 million live in communities that already have electricity. The more than 100 million beyond the electricity grid can be reached by extending the grid system or using decentralized household or village systems. Encouraging the 200 million that live in communities with electricity to adopt it will be quite challenging since these people are mostly rural and poor. But reaching them will not be extremely difficult or expensive since grid electricity is already nearby. The next chapter examines the barriers to household adoption to better understand the policy alternatives necessary for reaching those without electricity. The benefits of reaching those who have not adopted electricity will be quite large for both these households and India as a whole.

Notes

1. This exercise focused on lighting-only users to ensures that the costs computed were limited to lighting service.
2. The application of consumer surplus to value the benefits of electricity occurred as early as the mid-1970s (Anderson 1975). A more elaborate exploration of the concept followed in the mid-1980s (Pearce and Webb 1985). This increasingly popular approach has been applied in rural electrification projects implemented in such diverse countries as the Plurinational State of Bolivia, Lao PDR, Peru, and the Philippines (World Bank 1985, 2006, 2008; O'Sullivan and Barnes 2006).
3. The 2005 consumer surplus figure of Rs. 245 (that is, switching from a kerosene wick lamp to a 40-W bulb) is projected to 2010 using inflation to Rs. 616.
4. It is assumed that consumer surplus for lighting is cumulative over 20 years and that cash flow is discounted at a rate of 5 percent. The consumer-surplus scenario assumes that, for those without electricity, population and population growth would be the without-intervention case. For those that already have electricity, population growth would be covered under a business-as-usual scenario; their benefits are not included in these figures even though they would have to be covered by utility investments.

CHAPTER 3

Barriers to Household Adoption

Abstract

India's brisk pace of village electrification has not been matched by adoption at the household level. Even where electricity service has been locally available, many village households choose not to adopt a connection. Yet, with appropriate policies in place, electricity service could be within reach for most households, including even the poorest ones. This chapter examines the main barriers to achieving high household connection rates in India's rural and urban areas to better understand the policies needed to encourage even the poorest households to adopt electricity. The next section summarizes the literature review on barriers to grid extension in India. Subsequent sections identify key factors that influence rural households' decision making, including power supply reliability and the affordability of adopting electricity.

The Gap between Electricity Access and Adoption

The impediments to India's extension of grid electrification in remote rural villages and at the household level have been fairly thoroughly studied. The main reasons for not adopting grid electricity appear to be the remoteness of the village, India's electricity pricing policies, household characteristics of families, and reliability of the power supply.

Kemmler (2006) and Oda and Tsujita (2010) find a significant negative correlation between the remoteness of an area and both household and village electrification. Kemmler observes that in India rich agricultural areas tend to have high village electrification rates. In addition, Modi (2005) discusses the sheer number of households without electricity in remote villages. This fact, combined with India's population growth, is a potential hindrance to rural grid extension. Modi concludes that there is a lack of capacity in manpower, materials, and institutional support at the district and state levels for creating the necessary franchises to manage distribution systems. In terms of household energy-use patterns, Bhattacharyya (2006) concludes that rural electrification projects are unlikely to be financially viable without expansion of productive uses, a finding consistent with Kemmler's view of the importance of electricity in agricultural areas.

High connection charges and tariffs, as well as poor-quality power supply, which can negate households' benefits from electricity, may explain why many poor households living in villages that already have power lines and transformers choose to remain without electricity (World Bank 2002; Modi 2005). While Kemmler (2007) finds that tariffs and per capita expenditure have a relatively small effect on household adoption, he too suggests that quality of power supply affects household adoption rates; he also highlights the important role of education in a household's decision to adopt electricity. Another potentially significant characteristic found to discourage household adoption include the unsuitability of home construction materials and complex bureaucratic procedures for obtaining a supply (World Bank 2002).

Determining why household-level adoption continues to lag behind village electrification requires a better understanding of the supply-and-demand problems that characterize the gap between village availability of grid power and a household's decision to connect (box 3.1). According to India's National Sample

Box 3.1 Key Definitions Used in this Study

This study applied the following definitions used in India's National Sample Survey to disaggregate the electricity deficit of households in rural and urban areas:

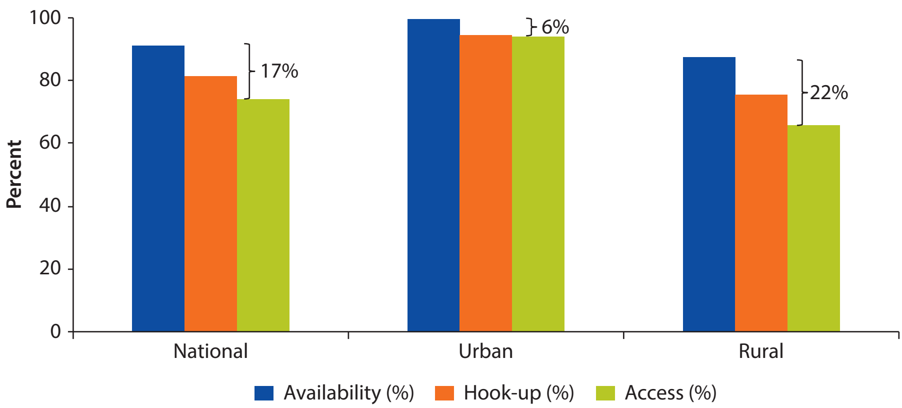
- *Availability rate* refers to the number of households for which electricity service is available as a proportion of the total number of households in the community. Electricity is considered available if at least one person in the primary sampling unit (4–8 households) uses electricity at home.
- *Hook-up rate* refers to the number of households using electricity service as a proportion of the number of households in communities where service is available.
- *Access rate* refers to the number of households using electricity service as a proportion of the total number of households; it is calculated as the availability rate multiplied by the hook-up rate.
- *Unserved population* equals 100 percent minus the access rate.
- *Pure demand-side gap* equals the availability rate minus the access rate.
- *Supply-side gap* equals the unserved population minus the pure demand-side gap.
- *Pure supply-side gap* equals the supply-side gap multiplied by the hook-up rate.
- *Mixed demand- and supply-side gap* equals the supply-side gap multiplied by 100 minus the hook-up rate.[a]
- *Proportion of deficit attributable to demand-side factors* only equals the pure demand-side gap as a proportion of the unserved population.
- *Proportion of deficit attributable to supply-side factors* only equals the pure supply-side gap as a proportion of the unserved population.
- *Proportion of deficit attributable to mixed demand- and supply-side factors* only equals mixed demand- and supply-side gap as a proportion of the unserved population.

Source: World Bank.

Survey, household adoption rates in villages with electricity increased by 9 percentage points between 2000 and 2010, narrowing the overall availability-access gap from 26 percent to 17 percent over the decade. In 2010, the gap was nearly four times greater in rural areas compared to urban ones, suggesting that rural households are much less likely their urban counterparts to connect to locally available electricity service (figure 3.1).

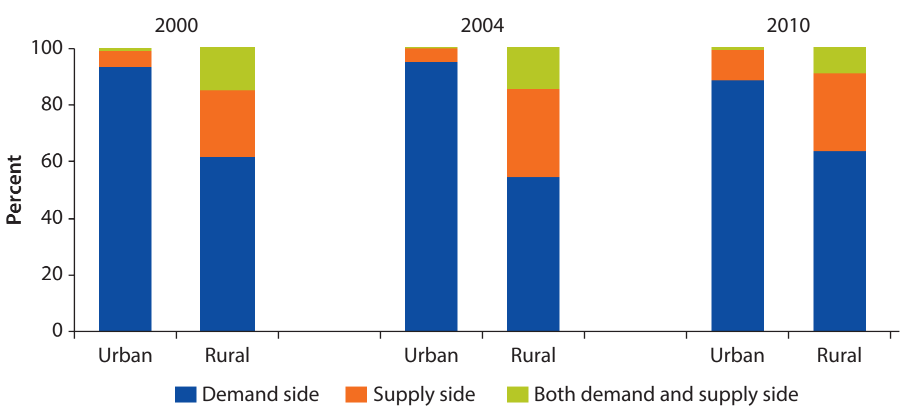
Today in India, demand-side issues figure more prominently than supply-side issues in explaining the access gap (figure 3.2). The current Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) focus on creating village electricity infrastructure is alleviating much of the supply-side barrier, and most people fail to adopt electricity for reasons other than unavailable power supply. This is not to say that India should discontinue extending electricity lines to the last 10 percent of its villages without power. However, it also means that the policies

Figure 3.1 Availability-Access Gap, 2010



Source: National Sample Survey 2010.

Figure 3.2 Urban and Rural Barriers to Adoption, 2000, 2004, and 2010



Source: National Sample Survey 2000, 2004, 2010.

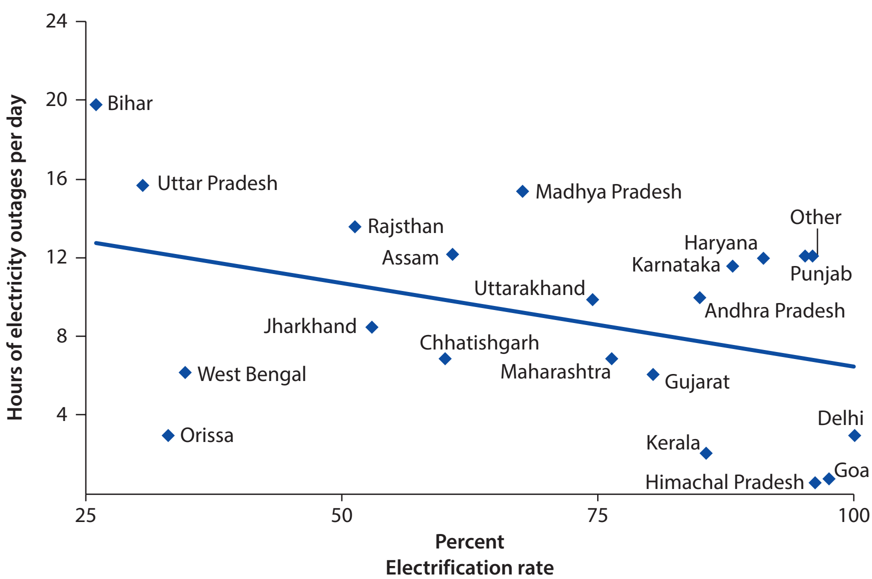
that create barriers to household adoption in villages with power have an equally important impact on India's remaining populations without electricity access.

Impact of Power Reliability on Electricity Adoption

Unreliable power supply undermines India's large investments in rural electrification and its significant benefits to both individual households and the country overall. Without lighting in the evenings, children cannot study and people cannot watch television. In farmers' fields, water cannot be pumped to crops, thus lowering yields. People without electricity are less likely to adopt service, reasoning that they should not have to pay monthly costs for a service that is unavailable at the times they need to use it. There is no use in investing in lines, transformers, and poles if power does not flow through them. Poor reliability also reduces the amount of revenue collected by the electricity companies, which, in turn, provides them little incentive to invest in maintaining service.

Rural India's power reliability problem is not limited to a few regions. Only about 7 percent of rural households with electricity report having no power outages. About one-fifth of households with electricity report outages of up to four hours a day, and the same number experience intermittent power supply throughout most of the day. Bihar and Uttar Pradesh—the two states that lag farthest behind in terms of both village coverage and household adoption—face the highest average daily outages (figure 3.3).

Figure 3.3 Electricity Outages, by Rural Electrification Rates for Selected States, 2005



Source: India Human Development Survey 2005.

To cope with the unreliable electricity supply, about 70 percent of grid-connected households use kerosene as a backup lighting source (table 3.1). These households generally pay a required minimum charge for electricity service regardless of the amount of electricity consumed. In addition, they spend about Rs. 26 ($0.6) per month on kerosene lighting, equivalent to purchasing 10 kilowatt-hour of electricity, assuming an indicative tariff of Rs. 2.5 ($0.06) per kilowatt-hour. The substantially higher amounts these households pay to meet their monthly lighting needs results in lost revenue for the state utility companies.

The reliability of power supply is directly related to the amount of money households have to spend on alternative fuels for household lighting. The 7 percent of grid-connected households that enjoy a reliable electricity supply use only 0.8 liters of kerosene for lighting each month. Conversely, the 18 percent of households that experience power outages more than 16 hours a day burn 2.2 liters of kerosene a month (table 3.2). In effect, such households are required to pay for two power sources to light their homes.

Lack of a reliable electricity supply is not just an inconvenience; there is a direct correlation between the extent of power outages and a village's household

Table 3.1 Extent of Kerosene Used for Household Lighting in Rural India, 2005

	Households without grid electricity			
Kerosene use variable	*In villages without grid*	*In villages with grid*	*In all villages*	*Households with grid electricity*
Households that use kerosene for lighting (%)	89.7	83.9	85.4	69.8
Kerosene used for lighting (liters/month)	2.72	2.21	2.34	1.76
Expenditure on kerosene used for lighting (Rs./month)	47.7	36.0	39.1	25.7

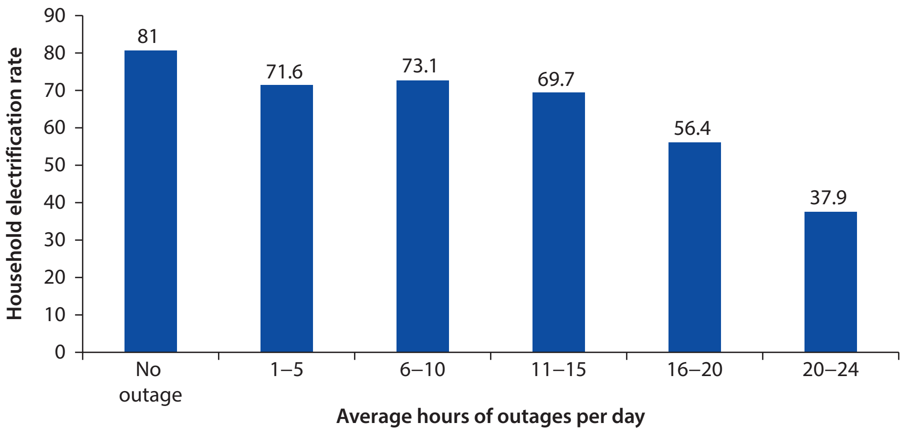
Source: India Human Development Survey 2005.
Note: The exchange rate used is $1 = Rs. 44.1 (World Development Indicators figures for 2005).

Table 3.2 Power Outages and Kerosene Use for Households with Grid Electricity, 2005

Household group by power outage duration (hours/day)	*Distribution of households (%)*	*Households that use kerosene for lighting in each group (%)*[a]	*Kerosene used for lighting (liters/month)*[a]
No outage	6.8	47.8	0.77
1–4	18.0	62.4	1.24
5–8	21.2	73.5	1.99
9–12	15.9	70.9	1.69
13–16	19.8	71.7	1.90
>16	18.3	77.6	2.21

Source: India Human Development Survey 2005.
a. Restricted to households that use kerosene exclusively for lighting.

Figure 3.4 Effect of Supply Reliability on Household Adoption in Electrified Villages, 2005



Source: India Human Development Survey 2005.

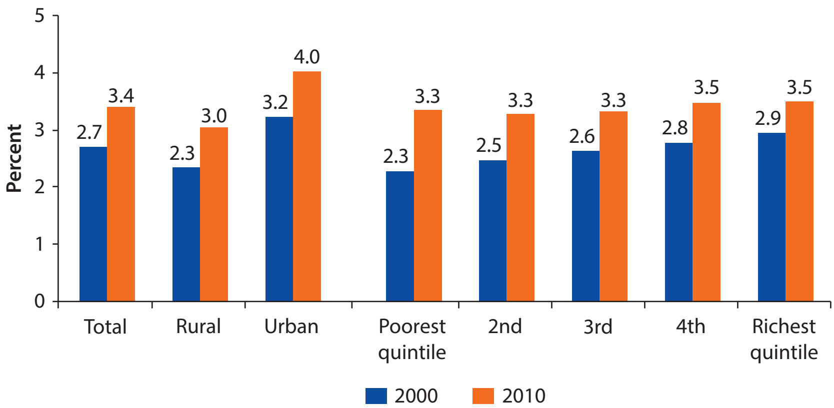
rate of grid electricity adoption. For example, in communities with daily service outages of 20 hours or more, the household adoption rate is just 38 percent, compared to more than 80 percent in villages with few or no outages (figure 3.4). After controlling for such factors as family size, education, and electricity price, greater reliability of electricity supply is associated with a higher probability of adopting electricity in villages where it is available. Raising the availability of electricity by just one hour per day increases the probability of household adoption by nearly 2 percent (appendix D). Many of the 200 million people living in villages with electricity would adopt power service if they could depend on electricity to be available to them when they flip the switch on their lights and appliances.

Household Affordability

The rationale often given for households not adopting electricity service is the expense involved in rural electrification. India's remaining households without electricity are poor, and the question is whether they can afford to pay a reasonable amount of their monthly income for electricity. One should keep in mind that such households already pay for kerosene for lighting. If power reliability in India were good, then nearly all of the kerosene expense could be directed toward paying for the benefits of electricity.

The patterns of power use in India confirm that electricity is quite affordable, even for the poorest households. For households with an electricity connection, the expenditure on electricity service accounted for just 3.4 percent of the average budget in 2010, a 7 percentage point increase over the previous decade. This expenditure level was remarkably similar across income quintiles. People with higher incomes tended to increase their spending on electricity, resulting in spending levels similar to those of other, less fortunate households; that is, electricity consumption increased at about the same rate as income.

Figure 3.5 Electricity Expenditure as a Share of Household Budget, 2000 and 2010



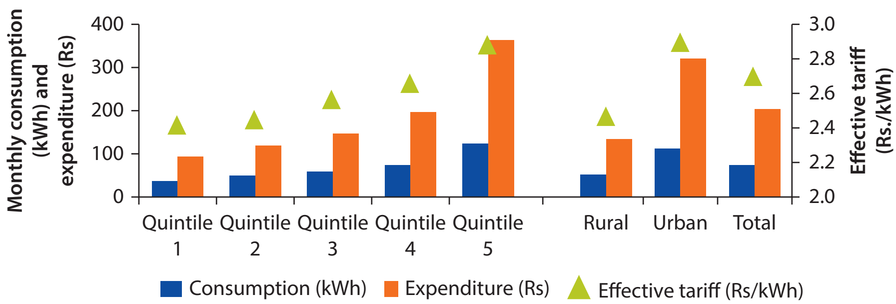
Source: National Sample Survey 2000, 2010.

Between 2000 and 2010, spending on electricity as a share of the total household budget rose for all income groups (figure 3.5). Over the decade, monthly electricity consumption increased by an average of 34 kilowatt-hour (from 42 kilowatt-hour to 76 kilowatt-hour). Poorer income groups exhibited the largest growth in electricity consumption proportionate to total household spending, reflecting the value they place on having electricity. The findings show that as people add more appliances over time, their use of electricity grows. Many of the factors holding back further use of electricity are related to its poor reliability, combined with the minimum monthly charges for service.

Rural and poorer households consume less electricity, and yet pay a similar price per unit as urban and richer households. The poorest households pay about Rs. 2.4, compared to Rs. 2.8 paid by the wealthiest households. This means there is little cross-subsidy between India's rich and poor households, a tariff feature used by many countries to make electricity affordable to their poorest people. The poorest households with electricity spend Rs. 92 ($2.0), compared to Rs. 363 ($7.9) spent by the wealthiest households. Monthly rural spending averages Rs. 133 ($2.9), less than half the amount of urban spending (figure 3.6). Spending also varies widely across states, from a high of more than Rs. 500 ($10.9) per month in Chandigarh and Delhi to a low of about Rs. 90 ($1.9) in Jharkhand, Sikkim, and Tripura, among others (appendix C).

Measuring the affordability of electricity service—an often-cited reason for poor people not adopting electricity—requires a number of assumptions. Given that households with electricity spend more than 4 percent of their income on electricity, the estimated affordability was assumed at 5 percent of the total household budget (box 3.2). For example, a household with a monthly income of Rs. 1,000 ($22) and a 5 percent affordability threshold could afford to spend a maximum amount of Rs. 50 ($1.1) per month on electricity service. If that amount were to exceed the representative monthly power bill, then electricity

Figure 3.6 Consumption, Expenditure, and Effective Tariff, 2010



Source: National Sample Survey 2010.

Box 3.2 Measuring Affordability of Electricity Service

To develop inferences on affordability, the study considered and compared two elements—the monthly electricity bill and the affordability threshold—drawing on a method developed by Foster and Yepes (2006) and subsequently used by Banerjee et al. (2008).

The **monthly electricity bill** is based on the spending patterns of households with electricity. For example, the poorest quintile spends about Rs. 90 ($2.0) per month on electricity, while the wealthiest quintile spends about Rs. 360 ($7.9) on average. At an average effective tariff of about Rs. 3 ($0.07) per kilowatt-hour, Rs. 90 ($2.0) will buy 30 kilowatt-hour, which is consistent with the government's vision of ensuring minimum household consumption of 1 kilowatt-hour a day.

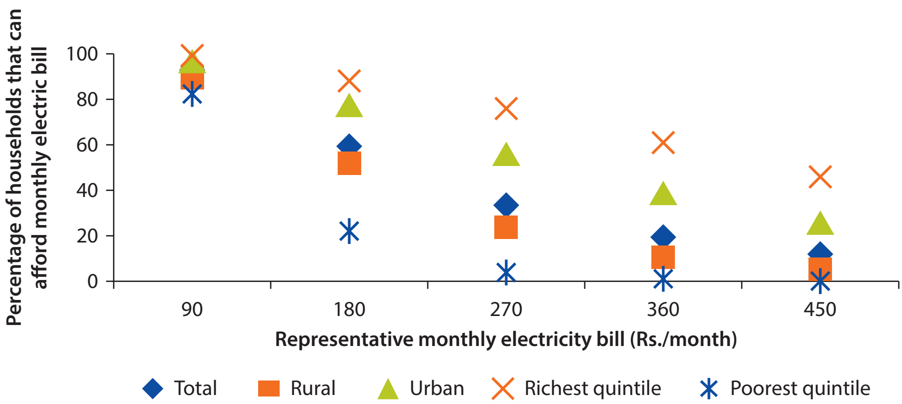
While there are no specific guidelines on setting the **affordability threshold** for electricity, more than 10 percent is considered prohibitive in the literature (Frankhauser and Tepic 2005). In this study, the affordability threshold was set at 5 percent of the household budget, which is the upper bound of what households spend on electricity today.

Source: World Bank.

would be considered unaffordable. Understanding affordability is important because the financial sustainability of electricity delivery depends on how much rural and lower-income consumers can afford to pay for service.[1]

Based on the 5 percent assumption, most rural households in India can afford to pay for electricity service. About 90 percent of rural consumers and 82 percent of the poorest income groups can afford to pay Rs. 90 ($2.0) per month, which is in line with what poor households typically pay for electricity service. However, if India were to raise electricity rates for the poorest households, their affordability would decline precipitously. At Rs. 180 ($3.9) a month, only 22 percent of the poorest consumers and 52 percent of rural consumers overall could afford to pay for electricity on a monthly basis (figure 3.7). At higher rates, the percentages decline even further. Thus, for the poorest income groups, the current level

Figure 3.7 Affordability of Representative Monthly Electricity Bill



Source: National Sample Survey 2010.
Note: Exchange rate in 2010: $1 = Rs. 45.7.

of expenditure on electricity is about the maximum they can afford. Policies to ensure the financial viability of the electricity companies must charge higher rates for those in the higher-income groups to make up for the affordability limits of the poorest households.

Summary Remarks

Many of India's 200 million people living within easy reach of electricity lines in villages with power choose not to obtain a connection from the state electricity companies. For even the poorest of these households, the draw of having electricity to take advantage of modern lighting and labor-saving devices is quite strong. This research finds that the barriers to electricity adoption involve power reliability; minimum monthly charges for electricity service; and, for a very small group, affordability of monthly electric bills. A surprise finding is that villages with unreliable power supply have high numbers of households that choose not to adopt electricity. Regardless of the quality of local service, the electricity companies charge a minimum monthly fee. In villages where power is unavailable during evening hours, potential customers obviously hesitate to spend a substantial portion of their monthly income on service that is not forthcoming.

Increasing electricity adoption in rural India will require enhancing the reliability of power supply. In addition, for those communities that have experienced many brownouts and blackouts, perhaps the level of minimum charges should be reviewed. Another possibility would be to provide consumers in villages with poor service reliability some type of rebate to compensate for substandard service. With appropriate service standards, the 200 million people without electricity could gain substantial benefits once they connect to the rural electricity grids. In addition, the electricity companies would benefit from improved revenue flows from already existing lines.

Electricity is quite affordable for the majority of even the poorest people in India. But the most minimal service might be unaffordable for the poorest households, who pay about the same or slightly lower tariffs than do wealthier households. Higher-income households could pay slightly higher electricity rates to make up for the lower revenues from those in the poorest income groups. Such cross-subsidy policies are fairly typical in many other countries with successful rural electrification programs. One should keep in mind that rates would not have to be drastically changed. The poorest income groups consume very little electricity, so only marginal increases in contributions from the higher-income groups would be needed to compensate for the lower prices paid by the poorest groups.

Note

1. As mentioned in chapter 4, RGGVY provides consumers below the poverty line (BPL) free household connections; however, they must pay a monthly charge like households above the poverty line (APL), who also pay the full connection charge.

CHAPTER 4

History of Rural Electrification and Institutional Organization

Abstract

For the past 60 years, India has had a strong program in place to promote rural electrification. The result has been dramatic progress in extending electricity service to the country's vast population. The past decade, in particular, has witnessed accelerated household adoption rates in poorer rural areas. This long-term growth in rural electrification has been accompanied by institutional problems that generally plague India's electricity sector. These include the poor financial condition of the state electricity companies, poor revenue recovery from agricultural pumping, lack of enough investments in operation and maintenance, and meddling by politicians in electricity expansion and service plans. These problems are fairly common, and have been experienced by many countries strongly committed to expansion of rural electrification. This chapter begins by examining how India's commitment to providing rural electrification has changed over the years, followed by overviews of institutional organization of rural electrification at national and state levels and ongoing grid and off-grid programs.

Evolution of Rural Electrification

Prior to the late 1960s, India's growth in rural electrification was extremely slow. At the time of the country's independence in 1947, only 1,500 villages had electricity. With the enactment of the Electricity Supply Act in 1948, power was extended to semi-urban and rural areas through the creation of the electrical grid system. But during that time, no mention was made of rural electrification. By the early 1950s, the focus of rural electricity supply had shifted to irrigation projects and village-level electrification. The goal was to provide electricity to 1 out of every 200 villages (table 4.1). The latter half of the 1950s saw a continued focus on village electrification. Also, special emphasis was placed on covering all towns with populations of 10,000 or above. By the end of the decade, coverage

Table 4.1 Timeline in the Evolution of India's Rural Electrification

	Five-year planning period		
Feature	*Activity focus/event*	*Key policies and programs*	*Electrification targets achieved*
I (1951–56)	Irrigation projects		4,231 villages
II (1956–61)	Rural electri-fication		14,458 villages; 350 towns (out of 856 targeted)
III (1961–66)	Sector efficiency and poverty alleviation	All-India Rural Credit Review Committee recommends creating the REC.	More than 25,955 villages (out of 37,000 targeted)
IV–V (1969–79)	Electric pump sets; village grid connections	REC created (1969); Minimum Needs Program initiated (1974).	More than 202,094 villages
VI–VII (1980–90)	Rural energy projects	Kutir Jyoti Yojana created (1989)	More than 237,371 villages
VIII (1992–97)	Economic use of rural power	MOP created (1992); MNRE created (1994); accelerated rural electrification program launched.	More than 11,666 villages
IX (1997–2002)	Rural electrification as prime mover of rural development	PMGY initiated (2001).	Some 13,317 villages; 86 percent village electrification achieved (2001)
X (2002–07)	Rural electrification redefined (2004)	AREP, REST mission, and RVE initiated (2002); Minimum Needs Program updated (2002); passage of Electricity Act (2003); National Electricity Policy created (2004); RGGVY launched (2005); Rural Electrification Policy created (2006).	More than 63,445 villages (including de-electrified)
XI (2007–12)		Rural Village Electrification Project, Special Packages, and Jawaharlal Nehru National Solar Mission launched.	More than 73,769 villages (including deelectrified)
XII (2012–17)	100 percent coverage expected by 2017		92 percent village electrification achieved (2012)

Sources: Krishnaswamy 2010; PricewaterhouseCoopers 2012; RGGVY website.
Note: AREP = Accelerated Rural Electrification Program; MNRE = Ministry of New and Renewable Energy; MOP = Ministry of Power; PMGY = Pradhan Mantri Gramodaya Yojana; REC = Rural Electrification Corporation; REST = Rural Electrification Supply Technology; RGGVY = Rajiv Gandhi Grameen Vidyutikaran Yojana; RVE = Remote Village Electrification.

had been extended to 18,689 villages; however, only 350 of the originally targeted 856 towns had been provided with electricity.

Productive-Use Emphasis in 1960s and 1970s Followed by Goal of Rural Development

In direct response to severe droughts and food shortages suffered in the early 1960s, India began to emphasize rural electrification's importance for improving productive uses. The goal was to encourage development by providing electricity for irrigation and commercial activities. The advent of higher-yielding grain varieties, as part of the Green Revolution, was one reason for rural electrification's emphasis on irrigation; without a steady water supply, the new seeds were ineffective. A by-product of the focus on productive uses was increased village electrification. Extending electricity to farmers and commercial enterprises meant that electricity was available in many rural communities. However, providing electricity to households was considered secondary. Power lines passed directly over households as they made their way to farmers' fields and commercial establishments.

From the late 1960s through the 1970s, the government encouraged farmers to purchase electric irrigation pumps. Electricity tariffs for agriculture were quite low. Also, credit schemes were put in place for farmers to purchase electric-powered irrigation pumps to create demand. Households were a second priority and would have to wait in line to be approved for gaining access to electricity service (Prayas Energy Group 2011). These policies actually succeeded quite well. Farmers adopted electric pump sets in massive numbers. However, the tariff subsidies, which outlived their original goal of converting farmers from rainfed to irrigated agriculture, remain in place even today. Owing to concentrated seasonal demand for electricity, the high expense of providing electricity lines for limited use, and the continuing subsidies for agriculture, the electricity companies lacked a strong financial incentive to service and maintain the electricity lines.

On recommendation of the All India Rural Credit Review Committee of 1966–69, the Rural Electrification Corporation (REC) was established in 1969 as a financing institution to promote investment in rural electrification, primarily for agricultural production. The REC's main objectives were to encourage electricity sector efficiency and alleviate poverty. It was also charged with extending financial assistance to state utilities for establishing generation, transmission, and distribution systems. Throughout the 1970s, the principal focus was on pump-set electrification and providing electricity to villages with populations above 5,000. Within a decade (1969–79), more than 202,094 villages had been provided with electricity. The REC's original mandate was broadened beyond agricultural production to include all forms of rural electrification. In 1974, rural electrification was included as a component of the Minimum Needs Program; thus, policies had shifted to serve rural households, but the strong emphasis on productive uses remained.

Finally, in the late 1970s, the Government of India turned its attention to rural household access to electricity. Starting in the 1980s, the government's successive Five-Year Plans have embodied conscious efforts to ensure investments in electrification through appropriate national-level schemes and programs. During the 1980s (sixth and seventh Five-Year Plans), the focus shifted to innovative rural energy projects. Such initiatives as the Integrated Rural Energy Program and Kutir Jyoti Yojana were put in place to address low rates of electrification in rural areas, especially among the poorest households. For example, under the Kutir Jyoti Yojana, the government provided a 100 percent grant to provide electricity for a single-point light source to households below the poverty line. Other programs centered on improved cookstoves (*chulhas*) and biogas plants, among others. Over the decade, a record 237,371 villages were provided with electricity. In the 1990s, the eighth Five-Year Plan (1992–97) emphasized economic use of rural power. Subsequently (1997–2002), rural electrification began to be viewed more as a prime mover of rural development.

Accelerated Grid and Off-Grid Efforts in Early 2000s

Since 2000, growth in both grid and off-grid electrification has accelerated, particularly in poorer rural areas. Under the Pradhan Mantri Gramodaya Yojana (PMGY), initiated in 2001, the government provided states a 90 percent loan and 10 percent grant for basic minimum services, including electrification. The Ministry of New and Renewable Energy (MNRE), created in 1994, launched the Remote Village Electrification (RVE) program in 2002 to provide lighting to remote villages using stand-alone, solar photovoltaics (PV) and other nonconventional energy sources. That year, the Minimum Needs Program was updated, whereby states with rural electrification rates below 65 percent were given 100 percent loan facilities to reach 100 percent electrification levels. Other major programs launched in 2002 included the Rural Electrification Supply Technology (REST) and the Accelerated Rural Electrification Program (AREP). Under REST, renewable energy and decentralized technologies generated electricity for villages from locally available resources. In addition, the AREP provided electricity companies with subsidized loans from the REC and other sources to promote rural electrification.

In 2005, the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) was launched to achieve the National Common Minimum Program objective of full household electrification within five years. All existing grid-related rural electrification programs were folded into the RGGVY. During the 11th Five-Year Plan, such national schemes as the Rural Village Electrification Project, Special Packages, and Jawaharlal Nehru National Solar Missions were initiated. The current expectation is that 100 percent coverage will be achieved under the 12th Five-Year Plan (2013–17).

The Electricity Act of 2003 established the legislative mandate and guidelines for improving electricity supply and delivery in rural areas. Through the 2004 National Electricity Policy and in compliance with the United Progressive Alliance's National Common Minimum Program, the central government announced the ambitious goal of achieving universal electricity access by 2009. In 2006, the Rural Electrification Policy laid out implementation guidelines through respective grid and off-grid programs.

Recent Policies, Institutional Roles, and Changing Definitions

The consequence of all the overlapping mandates for rural electrification is that, since the early 1990s, the institutional responsibility for rural electrification has grown more complex. The central government established policy and legislative frameworks to provide funding for centrally sponsored schemes. The states' role was to implement projects that were centrally designed and funded, along with their own state-financed schemes.

Reflecting the overlapping institutional mandates and shifts in program emphasis, key definitions have evolved.[1] In 1997, the government changed the definition of the term *rural electrification* to emphasize its critical role in rural development. That same year, it modified the definition of *village electrification* to specify use for any purpose in the inhabited locality of the village's revenue area. In 2004, rural electrification was again redefined. That same year, the definition of village electrification was expanded to include criteria for basic infrastructure (for example, having distribution transformer and lines in more decentralized locations, including Dalit basti hamlets), presence of electricity in public places (for example, schools, local government offices, health centers, dispensaries, and community centers), and minimum requirements to be considered as having electricity (for example, connection of at least 10 percent of village households).

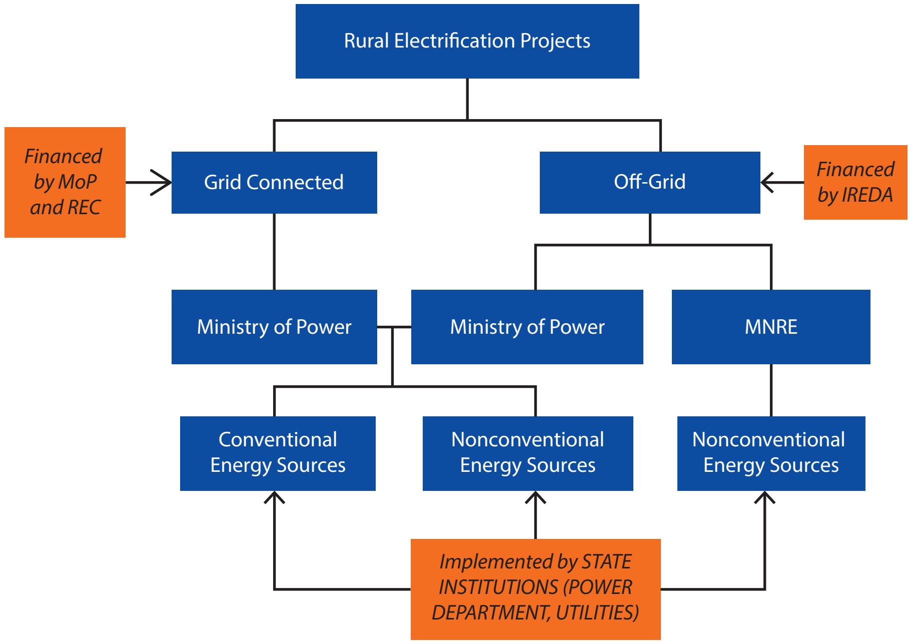
Institutional Organization

India's complex history of rural electrification has meant that several ministries and many agencies are responsible for the program. Although these institutions' roles have evolved over time, today their configuration is the result of this history; no doubt, there are ways to streamline these various responsibilities. This section describes the institutional responsibilities for rural electrification as they are currently organized in state and national organizations.

At the national level, India's electricity sector is governed by two ministries: the Ministry of Power (MOP), established in 1992, and the Ministry of New and Renewable Energy (MNRE), created in 1994 (figure 4.1). The MOP is responsible for general development of the electricity sector and implementing the landmark Electricity Act of 2003. The Rural Electrification Corporation (REC) and the MOP have overall responsibility for financing grid-based rural electrification. The MNRE is in charge of developing new and alternative energy technologies and promoting renewable energy. Finally, the Indian Renewable Energy Development Agency (IREDA) is the government's financing agency for off-grid and renewable energy–based rural electrification projects.

State-level institutions implement and at times cofinance projects that are developed by the central-level institutions. Government power departments lead state-level policy making in the electricity sector, including rural electrification policies.[2] Independent State Electricity Regulatory Commissions (SERCs) regulate state-level electricity sectors. Distribution companies or state electricity boards are responsible for urban and rural service delivery, as well as implementing rural electrification projects; typically, rural electrification is assigned to planning or engineering departments within these utilities. No state-level agencies or subagencies are dedicated exclusively to grid-based rural electrification. State-level agencies also serve as nodal institutions for promoting new and renewable energy development and off-grid electrification.

Figure 4.1 National-Level Institutional Organization of Rural Electrification



Source: Deloitte 2012.
Note: IREDA = Indian Renewable Energy Development Agency; MoP = Ministry of Power; REC = Rural Electrification Corporation.

National Policies and the RGGVY Program

Since the 2005 launching of Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), India has made significant progress toward achieving universal electricity access. The National Electricity Policy of 2005 laid out the ambitious goals of achieving 100 percent household access by 2009 and fully meeting power demand by 2012, with power supply to have achieved specified reliability and quality standards. This would be accomplished through improved system efficiency and reasonable electricity rates. By 2012, households were to have been provided a minimum subsistence consumption of 1 kilowatt-hour per day. RGGVY's main objectives were to extend electricity to all villages and habitations with more than 100 people, install small generators and distribution networks where grid extension was not considered cost-effective, and provide free electricity connections to households below the poverty line.[3] The MOP gave the REC responsibility for implementing the RGGVY. The 2006 Rural Electrification Policy established the guidelines, definitions, and institutional structure for the RGGVY program.

Complementing the RGGVY is the Remote Village Electrification (RVE) program, implemented by the MNRE. Supported by state-level renewable energy development agencies, this program provides financial support for providing decentralized energy sources to census villages in remote areas. It covers remote hamlets without electricity in villages that already have electric power. For hamlets in villages where grid extension is not cost-effective or covered under the RGGVY, the MNRE has programs using renewable energy to provide basic levels of electricity for lighting and other household needs.[4]

RGGVY projects focus on the following areas:

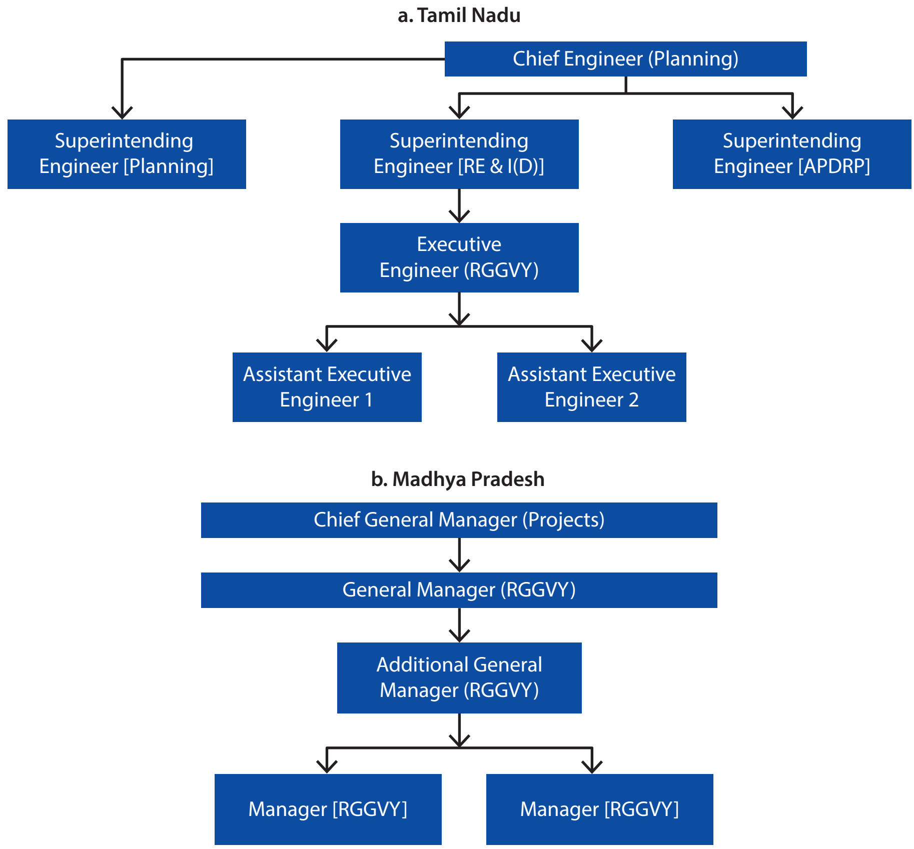
- *Rural Electricity Distribution Backbone*. Construction of 33/11 or 66/11 kilovolts substations and lines in blocks where they do not already exist.
- *Village Electricity Infrastructure*. Electrification of villages without electricity and habitations with populations greater than 100, which can be reached with electricity lines. The goal is to provide distribution transformers of appropriate capacity in every village and habitation with electricity.
- *Decentralized Distributed Generation*. Installation of small generators and distribution networks in villages where grid extension is not cost-effective and which are not covered by the MNRE's separate remote electrification program. The generation source can be conventional or renewable fuels, whichever is most suitable and economical.
- *BPL Electrification*. Provision of free electrification with 100 percent capital subsidy for all households without electricity below the poverty line (BPL) and nonsubsidized connection charges for households above the poverty line (APL).

The rural electricity distribution backbone, village electricity infrastructure, and decentralized distributed generation were envisaged to encourage the productive use of power for agriculture and other activities. These would include irrigation pump sets, small and medium-sized industries, *khadi* (cloth) businesses, and other village industries. Electricity could be used for refrigeration, health care, education, and information technology. Businesses provided with electricity would receive 90 percent capital subsidies, with the remaining 10 percent financed by REC loans or state finances.

The priority assigned to rural electrification and RGGVY depends on each state's level of electrification. For example, in Tamil Nadu, the electric utility's rural electrification department was quite active until the late 1980s, when the state achieved near universal electrification. At that point, the focus of the state electricity company shifted to strengthening its electric grid systems. Today, overall responsibility for the RGGVY rests with the state's chief engineer (planning), who also manages the Accelerated Power Development and Reforms Program (APDRP), the central government's flagship program for distribution loss reduction (figure 4.2a).

Madhya Pradesh, by contrast, continues to assign a high priority to rural electrification and RGGVY implementation. As of 2010, the state had provided 79 percent of its households with electricity. The state utility still lacks a rural electrification department. Instead, a project cell is headed by a chief general manager, who has a four-person management team dedicated to implementing rural electrification schemes (figure 4.2b).

Figure 4.2 Comparison of RGGVY Institutional Structure in Two States



Source: PricewaterhouseCoopers 2012.
Note: APDRP = Accelerated Power Development and Reforms Program; RGGVY = Rajiv Gandhi Grameen Vidyutikaran Yojana; RE & I(D) = Rural Electrification and Improvement (Distribution).

In the rest of India, some states follow the Tamil Nadu pattern of RGGVY implementation, while others follow the Madhya Pradesh example (table 4.2). Similar to Tamil Nadu, Andhra Pradesh, Gujarat, Karnataka, Rajasthan, Uttarakhand, and West Bengal assign mid-level officials responsibility for rural electrification. Like Madhya Pradesh, Assam, Bihar, Jharkhand, and Uttar Pradesh assign rural electrification a higher priority, and thus give top-level officials direct responsibility for rural electrification and RGGVY implementation.

The implementation of RGGVY project works are managed either by the state utilities or selected Central Public Sector Utilities (CPSUs), which have high levels of expertise in electricity project management. The CPSUs include Grid Corporation Ltd., National Thermal Power Corporation, National Hydro-electric Power Corporation, and Damodar Valley Corporation. The CPSUs hire appropriate local contractors to complete the electricity infrastructure projects. On completion, project assets are turned over to the relevant state utilities, which must then service new customers in the project areas. Under the RGGVY,

Table 4.2 RGGVY Implementation Features, by State

State	RGGVY BPL connections (number)[a]	Participation of CPSUs as implementing agency (yes/no)	Dedicated RE unit (yes/no)	Manager of RGGVY cell (title)	Officers in RGGVY cell (number)	First RE plan after launch of RGGVY (year)	Update to RE plan (yes/no)	State program on APL connections (yes/no; comment)	Distribution franchisees (yes/no)
Andhra Pradesh	2,702,633	No	No	Superintendent Engineer	3	2011	No	No	Yes
Assam	818,711	Yes	Yes	General Manager	5	2006	No	No	Yes
Bihar	2,172,686	Yes	Yes	Chief Engineer	8	n.a.	No	No	Yes
Gujarat	806,365	Yes	No	Superintendent Engineer	2	2008	No	No	Yes
Jharkhand	1,275,252	Yes	Yes	Assistant Executive Engineer	2	n.a.	No	No; Atal Gramin Electrification Scheme was announced but not implemented.	Yes
Madhya Pradesh	735,662	Yes	No	General Manager	4	2009	No	No	Yes
Orissa	2,750,947	Yes	No	Assistant Manager	2	2009	No	Yes; Biju Gramin Jyoti Yojana.	Yes
Rajasthan	1,056,009	Yes	No	Superintendent Engineer	4	2008	No	Yes; Mukhya Mantri Sabke Liye Vidyut Yojana.	Yes
Tamil Nadu	501,202	No	No	Executive Engineer	2	2008	No	No	No
Uttarakhand	230,558	No	No	Superintendent Engineer	2	n.a.	No	No	Yes
Uttar Pradesh	1,044,494	Yes	No	Chief Engineer	3	2009	No	No	Yes
West Bengal	1,957,723	Yes	Yes	Executive Engineer	3	2008	No	Yes; Rs. 379 ($8) per connection for APL consumers.	Yes

Source: PricewaterhouseCoopers 2012.
Note: APL = above poverty line; BPL = below poverty line; CPSUs = Central Public Sector Utilities; RGGVY = Rajiv Gandhi Grameen Vidyutikaran Yojana; n.a. = data not available.
a. As of April 2012.

Table 4.3 RGGVY Projects Managed by Central Public Sector Utilities

State	*Districts with RGGVY projects (number)*	*RGGVY projects (number)*	*Projects under CPSUs (%)*
Assam	7	7	30
Bihar	35	35	81
Chhattisgarh	12	14	88
Gujarat	2	2	8
Jharkhand	16	16	73
Madhya Pradesh	2	2	6
Orissa	30	32	100
Rajasthan	7	7	18
Tripura	2	2	50
Uttar Pradesh	8	10	16
West Bengal	10	10	36
Other	7	7	50
India	**138**	**144**	**25**

Source: RGGVY website.
Note: CPSUs = Central Public Sector Utilities; RGGVY = Rajiv Gandhi Grameen Vidyutikaran Yojana.

the CPSUs have been responsible for implementing rural electrification projects in some 138 districts across 12 states (table 4.3). The CPSUs are assigned the difficult work, while RGGVY responsibility within the utilities is assigned to relatively junior employees. For example, in Orissa, where privatized utilities have fewer employees compared to state electricity companies, assistant managers are responsible for rural electrification and the RGGVY.

Summary Remarks

The institutional organization of rural electrification is complicated, spanning two national ministries, a national financing agency for renewable energy, state electricity companies, and state renewable energy nodal agencies. With overlapping responsibilities and no single institution in charge, conflicts are almost inevitable. The complicated responsibilities and incentives to serve rural customers have led to challenges for program execution, which are examined in the next chapter.

Notes

1. Details on definitions are available at http://rggvy.gov.in/rggvy/rggvyportal/def_elect_vill.htm.
2. West Bengal is the only state to have established a dedicated rural electrification institution, the West Bengal Rural Energy Development Corporation; however, in 2007, it was merged with the state distribution company.

3. The RGGVY consolidated all currently ongoing rural electrification programs: Kutir Jyoti Yojana, National Minimum Needs Program, Pradhan Mantri Gramodaya Yojana, Accelerated Rural Electrification Program, and Accelerated Electrification of One Lakh Villages and One Crore Households.
4. RVE program details are available at http://www.mnre.gov.in/schemes/offgrid/remote-village-electrification.

CHAPTER 5

Challenges to Sustaining Progress

Abstract

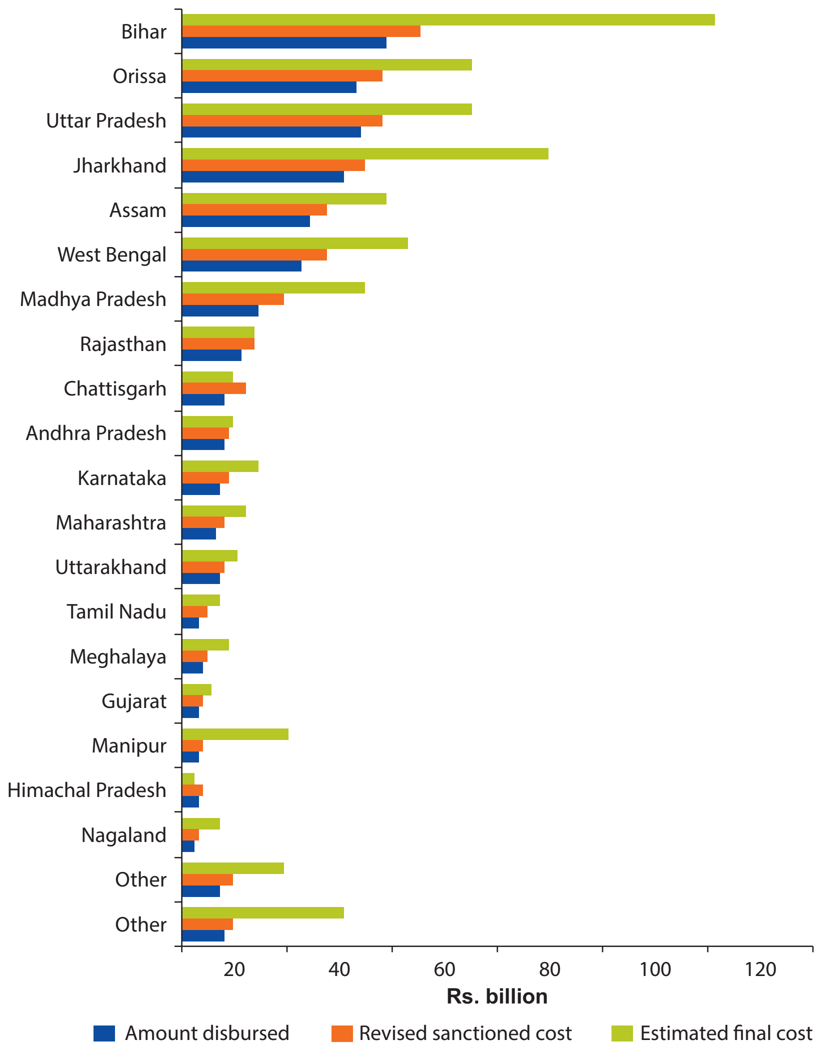
Despite India's accelerated pace of grid expansion, the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) program's future sustainability is challenged by the little revenue being realized from past investments in rural infrastructure. Hundreds of millions of customers experience unreliable service, while another 311 million—more than one-quarter of the population—remain without power. This chapter identifies the near-term challenges that are placing upward pressure on the already high cost of extending rural grid electricity, as well as the longer-term concerns that could potentially compromise the program's commercial viability. A number of the most successful state programs already have dealt with such problems, and they can provide useful lessons for overcoming the many challenges of rural electrification.[1]

Near-Term Financing and Implementation Challenges

The increasing costs of building new rural infrastructure and focusing on new connections are the result of several factors. The subsidies under existing programs are somewhat ineffective. The lines are built, but the state electricity companies have low incentives to serve those new customers. System planning is distorted by attempting to reach the poorest customers first, as most rural electrification plans move from those with potentially higher electricity use to those anticipated to have lower consumption. In some states, there is little attempt to improve the contracting efficiency of the state electricity companies. Finally, focusing on building lines, as opposed to serving those lines, results in a lower priority given to working with rural communities.

Under the RGGVY grid program, the Rural Electrification Corporation (REC) promises a 90 percent subsidy to cover the capital cost of grid extension and decentralized distributed generation (DDG) projects. In addition, a 100 percent subsidy is provided for covering new electricity connections for households that fall below the poverty line (BPL). In practice, subsidy payments rarely cover the full costs of those connections, and disbursements are often delayed.

Figure 5.1 RGGVY Project Cost Comparisons for Selected States, 2013



Source: RGGVY website.
Note: The exchange rate used is \$1 = Rs. 45 (average for 2005–12). RGGVY = Rajiv Gandhi Grameen Vidyutikaran Yojana.

This places a financial burden on the state electricity companies, which are responsible for taking over the lines after they are constructed. As of January 2013, REC's total approved costs for all RGGVY projects represented just 58 percent of the estimated actual costs of power system construction and connections—Rs. 342 billion out of Rs. 590 billion (\$7.9 billion out of \$13 billion). Furthermore, the government had disbursed only 84 percent of the approved costs.[2] For all states, the amount disbursed for connecting new customers was less than the approved amount, ranging from 33 percent in Punjab to 90 percent in

Uttarakhand. For all states except Chhattisgarh, the approved cost was less than the estimated actual cost (figure 5.1 and appendix E).

Planning Gaps, Subsidy Inequity, and Lack of Community Focus

The financing problems have been caused by several factors. First, states sometimes have underestimated the funding required to meet RGGVY goals. Second, the central government has inadequate cost norms for the expense of expanding the grid systems to rural customers. Finally, once the actual costs are known, an unwieldy revisions process sometimes disallows their reimbursement.

Several interlinked issues have resulted in states underestimating their cost requirements. The detailed project reports that states are required to develop to request funding outline the projects needed to achieve RGGVY's goals. They include descriptions of the villages to be provided with electricity, the number of BPL households to receive free connections, and the new infrastructure required. However, these reports often have been based on out-of-date surveys. Also, the BPL household lists are sometimes based on general perceptions without supporting data. In addition, the RGGVY program does not extend free connections to households above the poverty line (APL). As a result, the cost estimates of many states have overlooked APL households. Furthermore, many states have failed to involve village *panchayats* (local self-government units) in planning, which has resulted in errors in estimating project requirements (box 5.1). Together, these problems have led to longer-term underestimates of cost and maintenance of the electricity network.

The standardized cost norms for RGGVY projects developed by the REC often are lower than state estimates presented in development planning reports. Project cost norms take into consideration plains, hills, and tribal areas (table 5.1), but they do not account for other relevant factors, such as geography or local cost of living. In addition, REC village-level norms do not account for the infrastructure capacity required to cover all residents. When state development planning report estimates differ from the cost norms, the REC advises the relevant agencies to either justify the difference or revise the projects (Lok Sabha Secretariat 2009). In several cases, this has meant that the REC approved lower amounts than those estimated by the states (PricewaterhouseCoopers 2012). The result is that many projects do not receive adequate financing. To account for such discrepancies, the REC revised the cost norms in 2008 (table 5.1); but some problems remain in the procedures for estimating project costs in ways that are fair.

The RGGVY now allows for originally approved costs to be revised upward by 29 percent.[3] However, the cost revision process is lengthy and unwieldy. For such reasons, many states are deterred from applying for revisions (PricewaterhouseCoopers 2012). Changes of up to 20 percent of overall project costs can be approved directly by the REC chairman and managing director, but changes above that amount can only be approved by a high-level committee within the Ministry of Power. Finally, the REC does not cover revisions caused by project delays or variations in the cost of materials.

Box 5.1 Taking a Community Focus: State Lessons in Building Sustainability

States that have taken a community focus and involved local villages in the RGGVY planning process from the start have experienced better field-level implementation and garnered greater local support and ownership, which have contributed to operational sustainability.

In Madhya Pradesh, for example, comprehensive planning by the state's three distribution companies established the electrification needs of villages and households across the state. The companies developed a system of community walk-through surveys to determine possible clustering of villages and households with and without electricity. These surveys fed into overall state-level electrification requirements, submitted to the State Planning Commission. Because the survey findings were checked against data sets from the 2001 census and 2002 National Sample Survey, the companies were reasonably confident of the status of household electrification.

Rajasthan has an active rural electrification program predating the RGGVY that engages with local officials on key issues. At all stages of project planning and implementation, the state's distribution company has worked directly with *panchayati raj* (local self-government units). A meeting organized with villagers, *sarpanchs* (village heads), and utility field staff detailed the proposed program and potential community benefits, giving community representatives a chance to ask questions. Twelve sarpanchs that provided particularly excellent input were each awarded Rs. 100,000 for their communities. As a result, both the distribution company and communities gained a better understanding of how projects would be implemented. Local support from villagers and political representatives improved field-level implementation, particularly on issues related to obtaining rights-of-way clearance and overcoming other obstacles presented by APL households.

In West Bengal, RGGVY project planning involved significant local participation. *Gram panchayats* and *panchayat samitis* (village-level institutions) were responsible for preparing development plans for their respective areas and monitoring project implementation. The power company obtained a list of BPL households from the panchayat and conducted an extensive walk-through survey, with the participation of local panchayats across all nonelectrified villages, to identify target households. The state power company complemented the survey with a GPS-supported mapping system. Survey efforts only partially succeeded because of conflicts between agencies, but the process improved planning for new electricity connections and brought state utilities closer to their customers.

Source: World Bank.

The RGGVY process for disbursing approved costs has many built-in delays. The procedure is for 90 percent of funding to be released in three tranches over the course of the project cycle. The final 10 percent is released after the project has been completed to the REC's satisfaction. Project completion and consequently funds disbursement can be significantly delayed by project implementation problems or difficulties in transferring ownership of the new infrastructure

Table 5.1 REC Cost Norms for RGGVY Projects

	Cost norms (Rs. million)	
Project type	*Plains area*	*Hill-desert tribal area*
Electrification of nonelectrified village	1.3, revised up from 0.65 in 2008	1.8, revised up from 0.65 in 2008
Intensive electrification of already electrified village	0.4, revised up from 0.1 in 2008	0.6, revised up from 0.1 in 2008
BPL connection	2,200, revised up from 1,500 in 2008	

Source: Lok Sabha Secretariat 2009.
Note: The exchange rate used was $1 = Rs. 45. BPL = below poverty line; REC = Rural Electrification Corporation; RGGVY = Rajiv Gandhi Grameen Vidyutikaran Yojana.

to service providers. Increased numbers of target beneficiaries and technical corrections in project design often are not reimbursed until projects are completed.

Service Delivery Choices and Management Constraints

To implement the RGGVY projects, states can engage either the state electricity utility or a Central Public Sector Utility (CPSU) to act as the project implementing and management agency.[4] If the latter option is selected, the infrastructure assets are taken over by the relevant state utility on project completion. Both choices have pros and cons, including implementation issues that are likely to delay project completion and increase project costs. Also, service delivery delays may incur legal costs that raise the indirect costs of projects or otherwise create cost increases that the REC will not reimburse.

The CPSUs' strong project management experience helps them to execute large RGGVY projects. However, most of the CPSUs are unfamiliar with electricity distribution projects. As a result, they often subcontract the work out to local private "turnkey" contractors. As a result, the CPSUs are far removed from the projects and are unable to assist with the many irregularities that may arise during implementation. At times, the CPSUs' heavy reliance on local contractors has not gone well, leading to the termination of some contractors because of nonperformance. In such cases, projects are turned back over to the state utilities. As one might expect, some local contractors have engaged the courts to be compensated for terminated contracts, sometimes resulting in even further project delays.

The CPSUs often act independently and fail to interact with the local state electricity companies. The use of local contractors often delays integrating the new distribution system into the utility's business system. In some states, issuance of bills for newly connected households is delayed by 6–12 months. Such issues cause delays or discrepancies in the certification and reporting necessary for the REC to release final project funds (appendix F). The perception of the state utilities is that the REC has bypassed them in favor of the CPSUs.

Like the CPSUs, the state utilities engage local contractors, but they have avoided the problems of the CPSUs owing to their greater expertise in distribution projects and closer connection to on-the-ground situations. At the same time, the state utilities lack the greater project management expertise of the CPSUs and thus are more easily overwhelmed by the substantial household coverage of RGGVY projects. Also, the state utilities often have less-advanced monitoring and reporting systems, which presents a challenge for reporting progress to the REC (appendix G).

The RGGVY's provision of free connections to only BPL households also has hampered the timely and cost-effective completion of projects. In many states, APL households have protested that they also deserve to be provided with electricity. In some cases, they have blocked the extension of the electricity networks across their land. In other cases, they have obtained legal injunctions to redress the issue of lines passing them by in favor of BPL households. In some states, APL households have rebelled against the subsidizing of BPL households by illegally tapping into electricity networks rather than connecting as paying customers (PricewaterhouseCoopers 2012). To avoid such problems, Andhra Pradesh, Jharkhand, Tamil Nadu, and West Bengal have chosen to extend free connections to APL households at their own expense.

Long-Term Risks to Sustainability

Currently, the RGGVY program faces the dual challenges of physically unreliable infrastructure that cannot accommodate full village load and a revenue stream from rural households that is insufficient to secure a financially sustainable system. These issues are exacerbated by the difficulty of appropriately pricing electricity while ensuring household affordability. Rajasthan offers a promising example of how states can implement innovative practices to overcome these obstacles (box 5.2).

Inadequate Load Planning and Service Reliability

Many states have planned for village electrification without considering that many APL households would connect to the grid. This was mainly because the RGGVY scheme offers only BPL households free connections. It is not surprising that those above the poverty line would want to gain access to electricity, but the focus on BPL households created a bias in the planning process. For example, many states installed transformers that lack the capacity to meet full village load. This resulted in the failure of distribution transformers and immediate service disconnection for some households. Over the long run, system reliability and the network's ability to provide sufficient hours of supply were put at risk.

The RGGVY's current and past efforts have focused on funding the construction of new rural infrastructure, largely ignoring the proportionate investments needed to strengthen system reliability. This problem has become particularly noticeable in states with high electrification rates that built their current systems in the 1970s and 1980s, which now are in need of repair and upgrading.

Box 5.2 Improving Utility Revenues: Lessons from Rajasthan

Rajasthan's distribution company—Jaipur Vidyut Vitran Nigam Limited (JVVNL)—has taken several key steps to increase revenue flows from rural areas. These innovative practices have resulted in improved loads and revenues and a steady decline in distribution losses.

Segregating rural feeder loads. JVVNL has separated its electricity lines for rural households from those for irrigation pump sets. Revenue from households is more important to the distribution company. Since farmers are charged a low fixed rate for electricity, segregating feeder loads allows the utility to supply households without experiencing the high electricity use of agriculture in the same region. This leads to improved revenue flows, but also is a rather expensive way to make up for artificially low electricity tariffs for agricultural pumping.

Eliminating electricity theft. JVVNL has come up with a relatively simple system for preventing the theft of electricity. The company systematically monitors electricity use through monthly random sampling of all consumers connected to the electricity network. Consumers who have illegally obtained electricity are then metered and presented with bills they must pay. As a result of these actions, the illegal use of electricity has declined, and JVVNL's revenue flows have improved. JVVNL does not punish consumers who have stolen electricity by cutting off their service. Instead, they simply tell them they must pay their bills. In other states, by contrast, consumers that are disconnected may remain without power for long periods of time, which decreases the utilities' customer base and revenue.

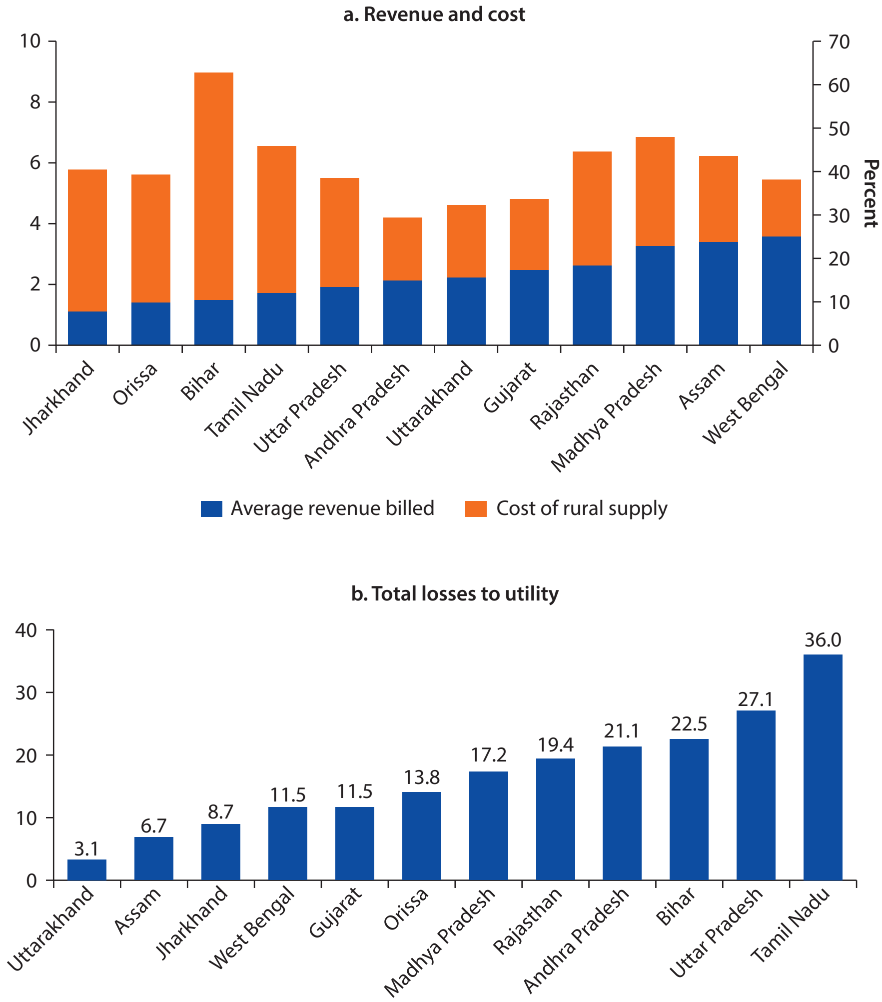
Lowering barriers to adoption. Rajasthan has developed an innovative program—Mukhya Mantri Sabke Liye Vidyut Yojana—to extend electricity to people living in sparsely populated rural settlements or hamlets. The state has 16,652 hamlets that could benefit from the RGGVY program, but the cost of connecting individual households in such remote areas is not economically feasible. Instead, the distribution companies concentrate demand by creating group connections. Each group of 4–10 households shares similar socioeconomic features. Group connections cost Rs. 3,500 ($76) per cluster, plus a Rs. 200 ($4.4) application fee. Such costs are shared to reduce connection charges per family. The group connections improve the load and revenue per kilometer of line, and increase the financial revenues collected by the electricity company.

Source: World Bank.

Insufficient Revenue and Commercial Viability of Utility

Once the electricity networks are constructed, the RGGVY transfers responsibility of funding service provision to the electric utilities or smaller franchisees envisioned to run the networks. But it is unclear whether these service providers can afford the investments required to maintain operable systems and assure households an adequate and reliable supply. The commercial viability of the service provider may be put at risk due to low prices and revenue streams not large enough to cover maintenance and upgrading of existing infrastructure.

Figure 5.2 Assessing Commercial Viability of Rural Service Delivery for Selected States, 2010



Sources: PricewaterhouseCoopers 2012 (figures 5.2a, b); Power Finance Corporation 2012 (figure 5.2b).

The reasons for the low cost recovery involve a number of actors. APL households are a potential source of revenue, but they are not part of the RGGVY program. Many are economically challenged and cannot afford the internal house wiring and connection charges required to obtain service. The tariffs of BPL customers are lower than those of other consumer groups, and even APL customers do not pay full cost. In 12 states, the average amount billed to rural consumers comprises less than two-thirds of the estimated cost of supply, ranging from just 16 percent in Bihar to 65 percent in West Bengal (figure 5.2a; appendix H).

Utility executives have confirmed that revenue from supplying new BPL consumers is too low to fund even basic revenue-assurance activities, such as customer billing and collection.

On average in these 12 states, the loss to the utilities from supplying rural consumers is about

The losses incurred by the electric utilities from serving rural consumers in these 12 states averaged about Rs. 3.6 ($0.08) per kilowatt-hour in 2010. The range of losses was also quite high, from a low of Rs. 1.9 ($0.04) per kilowatt-hour in West Bengal to a high of Rs. 7.5 ($0.16) per kilowatt-hour in Bihar. The states' combined burden of serving rural consumers totaled just under Rs. 200 billion ($4.4 billion).[5] In some states, the losses accounted for more than two-fifths of total distribution losses, illustrating the substantial burden on the utilities' financial status (figure 5.2b).

Summary Remarks

The goal of extending electricity to India's poorest rural consumers has overshadowed the need to provide reliable, quality service to all households with electricity. These are not conflicting goals. Within India, many states have reached near universal service by following well-established utility practices. But throughout the country, service reliability is an issue that requires more attention. Much of the electricity infrastructure constructed 15–30 years ago is in need of significant upgrading. The necessary investments will require good planning to improve revenues from existing lines. Better pricing strategies or subsidies that are transferred to the state electricity companies will be needed to improve power reliability. The current practice of building lines that cause the state utilities financial stress needs to be balanced with strategies that improve customer use of electricity and allow states to charge higher prices for more reliable service.

Today the utilities responsible for operating the network do not receive enough revenue to provide reliable service. In turn, unreliable supply discourages potential household customers from adopting electricity, further eroding the customer base and revenue flow. Poor reliability also means that meters are not running, thus limiting the resources available to operate and maintain the grid system. Reversing this trend will require a new approach that incorporates lessons from successful state strategies, along with international experience in successfully promoting rural electrification and achieving universal access.

Notes

1. This chapter is based on the findings of a background paper prepared by PricewaterhouseCoopers (2012).
2. Actual cost is estimated by calculating the cost per new connection released to date (that is, money disbursed divided by the number of connections released) multiplied by the total expected number of connections.

3. As of January 2013.
4. CPSUs include the Power Grid Corporation (India), National Thermal Power Corporation, National Hydro-Electric Power Corporation, and Damodar Valley Corporation.
5. This loss figure is estimated by calculating the product of the total number of rural consumers (using 2010 National Sample Survey data) and the gap between average revenue and average cost.

CHAPTER 6

Lessons from International Experience

Abstract

India has been one of the world's leading developing countries in providing electricity to both rural and urban populations. With the passage of time, however, there has resulted a complex web of various well-meaning policies and institutions that now are constraining efforts to connect the remaining populations without electricity—the last mile of the electricity grids. To reach these households, new thinking and policy reforms are needed to provide solutions that best meet these consumers' needs in financially responsible ways. The solutions might include extension of the existing electricity grid, guaranteed electricity reliability, new private or cooperative distribution companies, or off-grid renewable systems. Achieving the right balance between these and other options is a challenge that will last well into the future.

Based on international experience, a set of principles has been developed for the sound expansion of grid-based rural electrification programs (Barnes 2007). These principles include the sustained commitment of governments, as reflected in the development of effective institutions with a high degree of operating autonomy; the development of regularly updated rural electrification plans; and pricing electricity high enough to recover costs once lines are turned over to the distribution utility or other service provider. It is also important to work with communities to gain grassroots support for the program and lower the barriers to adoption for new customers desiring electricity. Finally, technical design standards should be customized to meet the expected low demand levels typical of more remote rural areas as a way to minimize investment costs. Drawing from these global principles, the following suggestions can contribute to India's efforts to improve electricity reliability and realize its goal of universal access.

Institutional Focus on Integrating Grid and Off-Grid Efforts

Create a new planning agency for grid and off-grid electrification. The most successful rural electrification efforts have benefited from dedicated agencies or units within existing electricity companies that focus primarily on encouraging, planning, and financing rural electricity lines that can be taken over and maintained by the existing company in a way that makes financial sense. In India, the Rural Electrification Corporation (REC) is a dedicated agency, but it deals mainly with financing and does not touch on the other issues. One way to deal with India's fragmented approach would be to create a national planning agency that coordinates grid and off-grid investments throughout the country. Such an agency, either stand-alone or housed within a relevant stakeholder institution, would lead the development and regular updating of the rural electrification plans and maintain an overall view of grid and off-grid interactions throughout the country.

Develop a coordinated approach between the Ministry of Power (MOP) and the Ministry of New and Renewable Energy (MNRE).[1] The rural electrification program needs to be guided by a transparent, long-term vision for coordinating grid and off-grid efforts. This vision should be supported by studies of low-cost technology options and public market studies of ability and willingness to pay. Deciding whether to implement a grid-based or off-grid solution requires a systematic appraisal rather than the nearly random allocation of sites for off-grid technologies that occurs in India today. For example, the lack of robust consumer market research has created a disconnect between estimated and actual costs of Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) projects. For the future, a more integrated approach between the MOP and the MNRE is needed to coordinate grid and off-grid schemes. For this coordination to occur, more reliable information is needed on populations without electricity, both in already electrified villages (for the electricity companies) and villages without power (for off-grid programs).

Transfer knowledge from the Central Public Sector Utilities (CPSUs). The Government of India and the REC have directly engaged with the CPSUs because of their project management expertise for RGGVY implementation. But they have not considered the need to transfer such knowledge and management practices to the state utilities. A close working relationship between the state utilities and the CPSUs would contribute to successful RGGVY implementation. In addition, building flexibility into the schemes would enable certain utilities—particularly those in states with better implementation capacity—to use their existing staff and resources, instead of hiring outside firms, to complete projects. This is important to ensure sustainability of the physical infrastructure and iron out implementation-related challenges.

Promote franchises. As part of its effort to provide better electricity service, the RGGVY has supported the development of electricity franchises. To date, rural franchises have only been engaged in revenue collection. Few service franchises that act like retail electricity businesses that purchase bulk electricity from utilities and resell it to customers have come forward to participate in the RGGVY program. One requirement for such a franchise system is a reliable supply of electricity because selling electricity is a prerequisite for any type of franchise profitability.

Concessions based on minimum necessary subsidies to attract the private sector operating distribution franchisees in rural areas might be considered. Such concessions could be awarded on a competitive basis, with a minimum assured supply from the distribution companies. For off-grid operators, an assured local generation plan could also be considered. The necessary subsidies to make such ventures attractive could be determined up front, based on existing experience with capital costs, or allocated according to the actual number of connections provided under an output-based aid mechanism. Such an approach would allow faster expansion and sustained operation of rural electricity services. Allowing for fair and flexible electricity pricing, rather than the prices charged by the state distribution companies, would provide incentives for the private sector to maintain high-quality service.

Planning and Load Development

Monitor the quality of service and connection information. Currently, distribution companies tend to reduce investment and operating costs in rural areas because of the perception that the business of rural electrification generates insufficient revenue. This underfunding leads to unreliable electricity supply. Thus, subsidies or incentives might be needed to ensure that appropriate investments are made in rural infrastructure. Compounding the problem, state distribution companies do not systematically keep track of regional power supply reliability or report outages; however, this is the information they need for regular monthly monitoring and reporting to the state's regulator and government.

Encourage the productive use of electricity to increase rural demand. One way to improve load development is to offer a bundle of complementary services as part of an integrated rural development agenda that encourages the productive use of electricity. Complementary services include access to affordable microfinance and knowledge and information, including education and training, dissemination campaigns, and available and qualified human resources. Complementary infrastructure (for example, roads, schools, information and communication technologies, and availability of business equipment) is also important. The experiences of such countries as Bangladesh, Indonesia, Peru, and Thailand suggest that the promotion of and capacity building for productive uses of electricity can increase the productivity of rural businesses, enable more efficient use of the supply infrastructure, and improve the revenues of distribution companies, thereby enhancing the economics of electrification.

In Peru, for example, a pilot project initiated in 2006 is expected to benefit some 9,000 families and microenterprises a using a Business Development Services (BDS) approach to promote productive uses of electricity. The implementing nongovernmental organization (NGO) uses BDS methods to assist home-based businesses and microenterprises to gather information, access credit, and address technology constraints through marketing and assistance campaigns. The strategy covers market assessment, preparation of business plans, marketing to the community and potential entrepreneurs, coordination with complementary institutions, and links with the distribution company. The pilot project concept has been integrated into the Peruvian government's national rural electrification plan, which includes capacity building for productive uses as a key objective.

Support local generation and supply. For communities beyond the grid, solar home systems (SHSs), local generation, energy-efficient lights, and other new technologies are now available at reasonable cost. These systems are not only competitively priced with grid systems; they are also quite reliable. In India, most efforts to promote such technologies have been based on central government approaches to product distribution, as opposed to development of markets by both retailers and NGOs. There are numerous contemporary examples around the world of rural energy agencies that provide the private sector, NGOs, and microfinance groups financing and grants to promote such initiatives. This can be done in coordination with the electricity distribution companies to create an incentive to lower peak loads typical of evening hours.

Given the speed with which villages are gaining electricity under the RGGVY program, most if not all villages will have access to grid electricity in the not-too-distant future. This prospect may create uncertainty for off-grid operators, but it may also be beneficial. Some communities in India already have mini-grids and small electricity systems that use renewable energy to supplement grid electricity service. But the evening load by itself is not high enough to justify private generation and supply systems because the costs outweigh the potential revenue. If these systems could sell electricity at marginal cost prices to regional or national electricity grids, as was done in Sri Lanka, many local generation projects could become financially viable. For this to happen in a coordinated way, cooperation on standards is needed to ensure that the grid and off-grid systems can work together. This is another reason why a national planning agency needs to be created.

The conclusion is that grid extension and off-grid options are not mutually exclusive and can be implemented in parallel. India needs to harness the potential of the utilities, private sector, regulators, communities, and financial institutions to create preconditions so that each stakeholder can individually benefit from and contribute to the universal access goal. India's dynamic private sector has revealed its capabilities when good business opportunities are present. Creating an environment in which the private sector can be innovative is the responsibility of the government and regulators.

Utility Cost Recovery and Supply Reliability

Use innovative metering and collection systems. The tariffs paid by customers that connect to the grid typically do not cover the full cost of providing rural supply. This is particularly an issue with BPL households, which often pay lower tariffs than other consumers; it is also an issue with above-poverty-line (APL) households. As discussed in chapter 5, the utilities are losing Rs. 3.6 for every kilowatt hour delivered in rural areas. Utility officials have indicated that the revenue from supplying new BPL consumers is too low to cover even the basic revenue-assurance activities, such as billing and revenue collection.

Therefore, conditions need to be created that (i) enable rural customers to continue paying their monthly bills and (ii) provide the utilities incentives to service them. Bill collection from rural consumers—no matter how small the bills—is a priority. Most of the service provided under the RGGVY scheme involves flat-rate tariffs. While this reduces the additional burden of meter reading and bill distribution efforts and allows households to consume more electricity without added expense, the result is greater revenue loss for the utilities.

In India, prepaid meters might be used to reduce the utilities' commercial risks and allow rural households to have more control over their consumption. In fact, the pay-as-you-go system is quite familiar to rural users of mobile-telephony, prepaid airtime cards.[2] Innovative, prepaid metering technologies allow customers to determine the percentage of their household incomes to spend on electricity in a given period and interact with their electricity providers through text messaging and other means to check balances. Another option for bill collection might be to turn over the responsibility to respected figures in the communities.

Other innovations, currently widespread in East Africa, allow rural consumers to make various payments through their mobile phones (M-Pesa system). This arrangement could be tried in India to further reduce transaction costs for all parties. It may be beneficial for some state utilities to explore management contracts with private operators who are able to deploy such new metering technology.

Improve reliability through dedicated generation capacity. Increasing access for the poor, particularly those at a subsistence level of consumption, is likely to require a relatively minimal increment of additional generation capacity. Indeed, the generation capacity to support India's access expansion in 2000–10 was 7 gigawatts, as compared with the total incremental capacity of 58 gigawatts the country added over this period. The generating capacity available for universal access must increase not only to provide for current households without electricity but also to improve reliability for currently served rural consumers. As the Prayas Energy Group (2011) suggests, this could mean allocating new pithead-based coal stations or central-sector hydro stations to serve newly electrified households. The other options are to manage current capacity shortages using a transparent system of scheduled load shedding, which can be publicly announced using media outlets, and strengthening the rural transmission and distribution infrastructure to reduce system losses and increase the amount of energy that can be delivered.

Lower Barriers to Adoption

Improve maintenance of rural distribution lines. Essential to the success of lowering connection costs is a political commitment to examining the various low-cost electrification approaches as part of a broad plan to improve access. In India, having reliable electricity supply is critical to improving rates of household adoption in villages that already have grid electricity service. Thus, improving the rural distribution systems must be assigned a higher priority to achieve a better balance with the focus on establishing new connections.

Provide free connections to APL households to improve load and financial return. At present, the RGGVY program provides BPL households free connections. But APL households, which often reside in the same neighborhoods as BPL households, may be unable to afford the upfront costs of electricity service (for example, internal house wiring and connection charges). As discussed in chapter 5, the exclusion of APL households has caused various problems, including illegal tapping of electricity networks and not consenting to the extension of the electricity network across land under their ownership. In some cases, legal injunctions have been obtained to prevent project discrimination on economic grounds. To avoid such problems, some states (for example, Andhra Pradesh, Tamil Nadu, Jharkhand, and West Bengal) have chosen to extend free connections to APL households at their own expense. Since most of India's rural households without electricity are poor, having an artificial poverty line that gives priority to those at the very bottom of society, however noble, would only appear to make implementing universal electricity access for all a more complicated process.

Most countries worldwide have at least a minimum service fee for gaining access to grid electricity. Free connections for those without electricity would not be prohibitively expensive for India, but for first-time users, some type of affordable minimum charge is necessary to cover basic paperwork. A review of connection fees, reconnection charges, minimum charges, and service reliability would be a priority to understand why many of the poorest households in villages with power are choosing not to adopt electricity. A caveat is that free electricity connections, combined with low electricity prices, would be quite problematic for the long-term financial viability of rural service delivery.

Community Involvement and Service Orientation

Improve avenues of customer interaction. Pathways need to be developed for customers to have more contact with electricity companies. Local units within companies could be created to deal with rural service problems and develop solutions. Community-outreach liaison officers are a standard feature in most developed countries. The electricity companies need to give higher priority to, and perhaps enhance the job status of, those dealing with customer service, system reliability, and reduction of power outages. Overall, better trust needs to be developed between the electricity utilities and their customers. Improving relationships might involve community representatives that can report problems or request new service for customers. In many countries, consumer meetings were held before the arrival of electricity, helping to avoid costly and time-consuming disputes over rights-of-way and construction damage.

Increase community participation and sense of ownership. Today, the low level of local participation in the RGGVY process is putting the future sustainability of rural service delivery at risk. International experience confirms the many benefits of involving local communities from the outset, including better designed programs (for example, Indonesia, Peru, and Vietnam), gaining of local support (for example, Bangladesh), mobilization of cash and in-kind contributions (for example, Nepal and Thailand), and increased local ownership, contributing to operational sustainability.

Communities can be involved in rural electrification in various ways. Authorized community members or political representatives can participate in bill collection or reporting outages or other problems to the electric utilities. Today, outages often go unnoticed for long periods, causing disenchantment among current and potential customers in the service area. Also, once the utility companies begin focusing on electricity problems in rural areas, they can hold regular meetings to inform consumers about the steps being taken to improve service. Other suggestions might involve such innovations as allowing bill payments by mobile phone or installing prepaid meters.

As discussed in chapter 5, some states in India have already begun to involve *panchayati raj* (local self-government entities), women's self-help groups (SHGs), and other community-based organizations in rural electrification programs. For example, Orissa's Nayagarh District, which already has more than 154 women's SHGs engaged as micro-franchisees, aims to create an additional 5,000 such groups to replicate the success across all distribution companies. Under the micro-franchising model, women's SHGs in West Bengal and Uttaranchal are actively engaged in more than 1,169 and 5,321 villages, respectively. But the lack of requisite skills sets and financial capability impedes the activities in which such village-level groups can be involved. For example, it would not be advisable for panchayat-level personnel to undertake operations and maintenance or capital-expenditure activities; however, they could be involved in registering new customers, meter reading, billing and collection, and disconnections/reconnections.

Lower Construction and Operation Costs

Redesign and change technical standards. Major opportunities exist to redesign India's rural electricity infrastructure to match design standards to electricity demand and ensure that operating costs are not overshadowed by capital construction for new lines. Where the main expected household uses of electricity are lighting and small appliances, typical of many rural areas, there is no reason to apply design standards used for more heavily loaded urban systems. The rural distribution system can be designed for actual loads, often no more than 30–50 kilowatt-hour per month. Consumption usually grows at a slow pace; thus, if the necessary design provisions are made, systems can be inexpensively upgraded later on.

A new program may be necessary for the 200 million people in villages that already have electricity. The electricity industry should not lose sight of the lost revenue from the hundreds of millions of customers that experience outages, as well as those who choose not to connect to the grid because of poor service reliability. Strengthening existing distribution systems, along with providing remote-switching technology and smart grids, could lower costs by routing electricity on an on-demand basis.

Have regulators monitor service quality and create a linked system of incentives. Major investments have been made in rural electricity infrastructure, but little revenue is being realized from these massive investments because of power outages, low or flat-rate tariffs, and people not connecting because of low-quality service. State regulators need to effectively monitor and encourage higher service standards. One way to promote customer service would be to develop a system of subsidy payments linked to reliability with clearly defined quality parameters for electricity customers. Another option would be to allow electricity companies to charge higher prices once a certain level of service quality has been achieved. However, a careful balance is required between effective monitoring by regulators and allowing space for the development of innovative models by private-sector providers.

Moving Forward

The RGGVY program has made significant contributions to meeting India's challenge of rural electrification, having reached more than 90 percent of villages. Unfortunately, many households in those villages have not chosen to adopt electricity, which is quite unusual, considering the many benefits of electricity for rural households. It would appear that the vast majority of those households have the ability to pay for service, but are not convinced that it is in their best interest. Applying the principles outlined in this chapter can contribute to closing the access gap for the more than 200 million residents in grid-electrified rural villages that have not adopted electricity, as well as the 100 million more without access in remote off-grid areas.

India can achieve universal electrification by 2030. Success of the access expansion program will fall on the state electricity companies, but they will need support. At present, they are being provided with incentives through capital and other subsidies to string lines, or contractors are building the lines and turning them back over to the state electricity companies. Thus, owing to low electricity prices and/or lack of subsidies for operation and maintenance, the state electricity companies have had little incentive to serve those living along the electricity lines. The results have been poor reliability and loss of benefits for those with electricity service and a disincentive for those without electricity to adopt a connection.

Though the problems have been politically hard to overcome, the solution is not complicated. It can be accomplished by having a central institution responsible for more than just providing subsidies for lines. It should also be responsible for providing higher-quality service, charging a fair price to consumers and providers alike, focusing more on customer service, involving rural communities more in the process of electrification, and developing systems and technical standards more appropriate for rural levels of demand. As India enters a new age of modernization, it is important that electricity not only be provided to all of its citizens; the service offered should also be closer to levels found in the rest of the developed world.

Notes

1. Since June 2014, the two ministries are headed by the same minister.
2. More rural residents have cell phones than electricity connections.

APPENDIX A

Estimating Investment Needs for Universal Access

The study developed two load scenarios to estimate the investment needs for achieving universal electricity access by 2030 (box A.1). The first scenario is aligned with the central government's vision of providing each household at least 1 kilowatt-hour of daily consumption, while the second examines a more basic level of access through mini-grids or solar home systems (SHSs). Under the first scenario's assumption of 1 kilowatt-hour per day, the annual investment needs until 2030 would be valued at Rs. 139 billion ($3 billion), with a cumulative cost of Rs. 2 trillion ($62 billion) over the 2011–30 period.[1] The second scenario would require an annual investment of Rs. 108 billion ($2.4 billion), with a total investment of Rs. 2,160 billion ($48 billion). Although the required annual investment under either load scenario exceeds the $1 billion that the government currently spends on the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) program each year, this would be quite affordable, constituting only a small share of India's gross domestic product (GDP).

Box A.1 Envisioning Investment Needs: Two Load Scenarios

Scenario 1. This scenario assumes that each rural and urban household would have a demand of 1 kilowatt-hour per day (that is, 200-watt for five hours each day). In urban areas, the estimated unit cost per grid connection would be Rs. 13,500 ($300), and twice that amount for rural areas (Rs. 27,000 [$600]).The average unit cost per connection through mini-grids and SHSs is estimated at Rs. 36,000 ($800) and Rs. 18,000 ($400), respectively. These are ballpark estimates drawn from currently available pricing information. For example, a 100-watt solar mini-grid system with battery storage that permits running basic household services (that is, lights, phone charger, refrigerator, and television set), for 10 hours a day, would cost about $800 per connection. Similarly, a 100-watt SHS would cost about Rs. 18,000 ($400) per

box continues next page

Box A.1 Envisioning Investment Needs: Two Load Scenarios *(continued)*

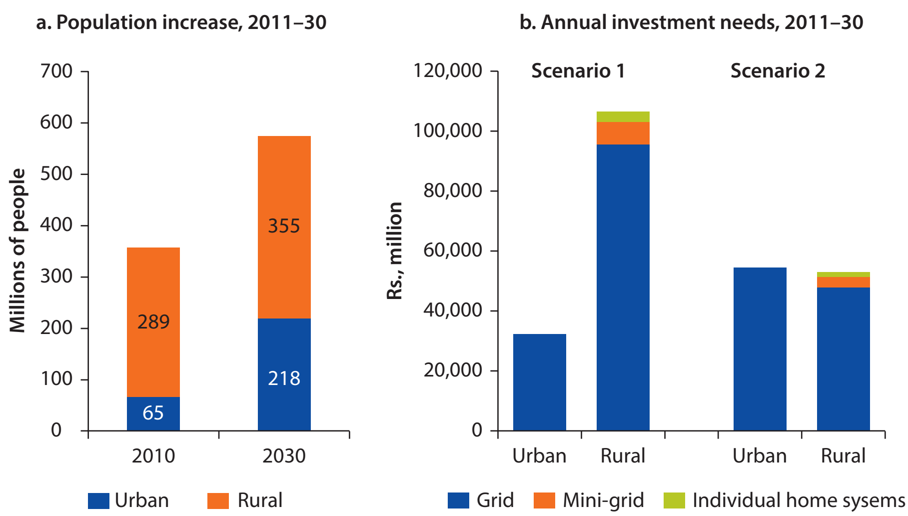
household. In this scenario, the annual cost of supply for achieving universal access by 2030 is estimated at Rs. 139 billion ($3 billion), with a cumulative cost of Rs. 2 trillion ($62 billion) over the 2011–30 period.

Scenario 2. In this scenario, rural households would be expected to consume less power than in scenario 1, owing to lower rates of appliance ownership and daytime usage, while urban loads would be higher. The new types of mini-grid systems and SHSs envisioned are designed for rural loads of about 50–100 watts. The energy-efficiency improvements of newer appliances in the last two-to-three years have dramatically reduced household power needs for basic energy-consuming tasks. Today, a 50-watt solar mini-grid, which comfortably allows for lighting, phone charging, and running a television set, costs about Rs. 18,000 ($400) per household. A 10-watt SHS used four hours a day costs about Rs. 9,000 ($200). In this scenario, the urban load is assumed to be twice the rural load (400 watts versus 200 watts) or about Rs. 22,500 ($500) per household. The total cumulative investment through 2030 is estimated at Rs. 2,160 billion ($48 billion), with an average annual investment of Rs. 108 billion ($2.4 billion).

Source: World Bank.

Nearly three-quarters of the required investment would be directed to rural areas, reflecting current access differences in rural and urban areas, along with the high cost of rural supply (figure A.1). Most of this investment would be directed to the poorest rural communities, thus helping to alleviate the vast divide between rural and urban, as well as rich and poor, households.

Figure A.1 Investment Needs for Universal Access by 2030



Source: World Bank.

Achieving universal access to electricity by 2030 is not financially prohibitive for India. The load scenarios presented above show that the required annual investments range from Rs. 108 billion ($2.4 billion) to Rs. 139 billion ($3 billion). Considering that the country already spends about Rs. 45 billion ($1 billion) a year on new electricity lines through the RGGVY program, this goal is quite achievable.

Note

1. This figure is much lower than that the $12 billion estimated by the International Energy Agency (IEA 2011).

APPENDIX B

Household Survey Data Description: National Sample Survey Organization

The study relied on data collected from household consumer expenditure surveys conducted by the National Sample Survey Organization (NSSO) during 2000–10. Data were collected from three annual survey rounds, and the combined household sample size was 250,795 (table B.1). Households were selected using random sampling, and most of the country's geographical area was covered. In this report, coverage figures are population weighted, and expenditure figures are household weighted since electricity payments are usually made at the household level.

Information on electricity and other fuel and light sources is located in the household consumer expenditure schedules (Schedule 1.0) of the surveys. These schedules collect information on quantity and value of household consumption with reference periods of "last 30 days" and "last 365 days." They also collect data on the main fuel sources for household lighting and cooking. This enables computation of access- and affordability-related measures by a range of variables, including state and income quintiles. Because all three National Sample Surveys were undertaken using the same method, the data are comparable across surveys.

Limitations of the Data

Household survey data have several inadequacies. First, data on energy spending can be fraught with inaccuracies because the data are self-reported by the surveyed households. The questions are based on actual payments rather than billed amounts, and it is difficult to distinguish between arrears and current payments. In addition, the surveys do not ask questions about metering, so it cannot be known whether household payments are based on specific billing and collection practices of the utilities. Second, wording of the survey questions can be confusing. Surveys may ask respondents to declare the payments they made "last

Table B.1 Total Sample Size for the Three Household Surveys

	55th round (July 1999–June 2000)		*60th round (January–June 2004)*		*66th round (July 2009–June 2010)*	
Composition	*First-stage units*	*Households*	*First-stage units*	*Households*	*First-stage units*	*Households*
Rural	6,208	71,385	4,908	18,975	7,512	59,119
Urban	4,176	48,924	2,708	10,656	5,272	41,736
Total	10,384	120,309	7,616	29,631	12,784	100,855

Source: National Sample Survey 2000, 2004, 2010.

month," even though payments were not due monthly in many cases. Third, information on quality of service provision is negligible. Surveys indicate whether electricity service is available and affordable, but not whether it is reliable or responsive to consumer needs. Sometimes spending patterns reflect reliability problems; for example, households and businesses incur tremendous losses from unreliable and infrequent electricity service, meaning that they must spend funds for alternative energy sources. Such information, where available, has significant policy implications.

Variation in Access Rates

Households answer several survey questions on electricity use, including their primary source of energy for lighting and cooking, how much they spend on electricity, and associated kilowatt hours of consumption. Whenever a household reports zero electricity expenditure, it also reports zero kilowatt hours of consumption; however, it is unclear whether this is a natural occurrence or the outcome of the survey design. In the majority of cases, when a household reports using electricity for cooking, it also reports using electricity for lighting.

Nearly all households report electricity expenditures if they cite electricity as their primary energy source for lighting; the converse is also true. However, approximately 0.5 percent of households report using electricity as their primary energy source for lighting, yet report no electricity expenditures. Similarly, 1.6 percent of households that report nonzero electricity expenditures do not cite electricity as their primary energy source for electric lighting and, in most cases, cooking.

In this context, there are two alternate methods for defining electricity access: (i) whether a household reports using electricity for such basic activities as lighting and (ii) whether a household reports paying for electricity consumption. Given the anomalies described above, these two measures yield slightly different access rates. Defining "access" as using electricity for lighting generates an access rate of 73.9 percent, while defining it as having electricity expenditures yields an access rate of 74.6 percent (2010 figures). If it is defined as using electricity for lighting or having nonzero electricity expenditures, an access rate of 75.7 percent is obtained. However, this is likely a flawed methodology; that is, it corrects for households that report paying for electricity but do not report using it for lighting, but not for households that report no electricity consumption yet report using electricity for lighting.

Using census data instead of the Nation Sample Survey data suggests a lower access rate of 67 percent. Both the census and the National Sample Survey collect information on energy sources for lighting. In the census, households are asked about their “main” source of fuel for lighting (that is, electricity, kerosene, solar energy, other oil, any other, no lighting), whereas the National Sample Survey asks households about their “primary” source of lighting for the last 30 days preceding the survey date. The 65th survey round notes that electricity for domestic use might be for lighting, cooking, or both. Moreover, electricity might be used legally or illegally, and electricity might be supplied to the household through public agencies, corporations, or private suppliers. However, if the household devised its own electricity arrangements, using either a generator or solar panels, the household was not considered as having electricity.

APPENDIX C

Data Tables

Table C.1 Percentage of Population Using Electricity as Main Lighting Source

	2000	2004	2010							
State or union territory	*Total*	*Total*	*Total*	*Rural*	*Urban*	*Quintile 1*	*Quintile 2*	*Quintile 3*	*Quintile 4*	*Quintile 5*
Andaman and Nicobar Islands	74	87	91	87	97	100	60	58	89	98
Andhra Pradesh	75	81	95	94	96	89	93	94	97	97
Assam	31	34	51	45	88	27	37	59	77	93
Bihar	14	13	25	19	70	14	23	35	39	76
Chandigarh	96	96	87	100	85	100	87	81	97	87
Chhattisgarh	n.a.	60	78	75	92	71	83	83	84	97
Dadra and Nagar Haveli	95	98	100	100	100	100	100	100	100	100
Daman and Diu	99	86	100	100	100	100	100	100	100	100
Delhi	96	96	99	100	99	56	97	100	98	100
Goa	96	100	99	99	99	100	100	95	100	99
Gujarat	84	85	93	91	96	81	86	92	98	99
Haryana	85	90	96	95	97	75	91	96	98	99
Himachal Pradesh	95	94	98	98	95	97	97	98	97	98
Jharkhand	n.a.	34	55	45	92	33	54	67	76	91
Karnataka	80	86	97	96	98	96	97	94	97	100
Kerala	73	82	94	93	96	85	89	92	94	96
Lakshadweep	98	100	100	100	100	100	100	100	100	100
Madhya Pradesh	70	79	79	73	98	72	73	81	88	99
Maharashtra	84	83	90	85	97	74	82	90	93	98
Manipur	76	85	91	90	96	72	88	94	97	99
Meghalaya	56	63	81	77	99	60	73	84	83	98
Mizoram	81	92	86	76	98	56	60	86	92	97
Nagaland	88	99	99	100	99	100	96	100	99	100

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Table C.1 Percentage of Population Using Electricity as Main Lighting Source *(continued)*

	2000	2004	2010							
State or union territory	*Total*	*Total*	*Total*	*Rural*	*Urban*	*Quintile 1*	*Quintile 2*	*Quintile 3*	*Quintile 4*	*Quintile 5*
Orissa	27	40	56	51	87	33	59	79	88	96
Pondicherry	86	90	100	100	100	100	100	98	100	100
Punjab	95	93	96	95	98	94	91	95	97	99
Rajasthan	59	60	77	71	96	53	65	78	84	94
Sikkim	93	92	96	95	100	71	88	99	98	100
Tamil Nadu	80	86	97	96	98	90	95	97	99	99
Tripura	50	68	77	73	95	53	70	74	89	99
Uttar Pradesh	36	39	43	32	80	21	34	49	61	77
Uttarakhand	n.a.	68	94	93	96	76	86	92	97	99
West Bengal	36	46	59	48	92	38	48	57	80	93
Other	47	55	72	65	95	51	63	63	77	88
Other	97	98	97	97	99	97	98	96	98	98
Total	**59**	**64**	**74**	**66**	**94**	**47**	**63**	**77**	**87**	**96**

Source: World Bank.
Note: n.a. = not available.

Table C.2 Percentage of Population Using Kerosene as Main Lighting Source

			2010							
State or union territory	*2000 Total*	*2004 Total*	*Total*	*Rural*	*Urban*	*Quintile 1*	*Quintile 2*	*Quintile 3*	*Quintile 4*	*Quintile 5*
Andaman and Nicobar Islands	24	12	9	13	3	0	40	42	11	2
Andhra Pradesh	24	19	4	5	1	11	6	5	2	1
Assam	68	66	48	54	8	72	62	41	23	2
Bihar	85	86	74	80	27	84	76	64	59	23
Chandigarh	4	0	1	0	1	0	9	8	2	0
Chhattisgarh	n.a.	40	17	20	4	25	12	11	12	1
Dadra and Nagar Haveli	5	2	0	0	0	0	0	0	0	0
Daman and Diu	1	0	0	0	0	0	0	0	0	0
Delhi	2	0	0	0	0	0	3	0	0	0
Goa	3	0	1	1	1	0	0	5	0	1
Gujarat	15	15	7	9	4	19	14	8	2	1
Haryana	12	9	2	3	1	22	4	2	1	0
Himachal	4	5	2	2	1	3	3	1	2	1
Jharkhand	n.a.	65	44	54	7	66	45	33	23	8
Karnataka	20	14	3	4	2	4	3	6	2	0
Kerala	26	18	5	6	3	15	10	7	5	2
Lakshadweep	0	0	0	0	0	0	0	0	0	0
Madhya Pradesh	30	21	20	26	2	27	26	19	11	1
Maharashtra	16	16	9	14	2	26	16	9	7	1
Manipur	22	15	8	10	3	27	11	6	3	0
Meghalaya	42	36	18	22	1	40	26	14	16	2
Mizoram	10	7	9	15	0	31	23	10	5	1
Nagaland	10	0	0	0	1	0	0	0	1	0
Orissa	72	59	43	49	12	67	40	21	12	2
Pondicherry	13	10	0	0	0	0	0	2	0	0
Punjab	4	4	1	2	1	5	6	2	0	0
Rajasthan	39	38	21	27	4	46	32	21	15	5
Sikkim	5	7	4	4	0	29	12	1	1	0
Tamil Nadu	19	14	3	4	2	9	5	3	1	1
Tripura	50	31	23	27	5	47	30	26	10	1
Uttar Pradesh	62	60	56	67	16	78	66	50	37	15
Uttarakhand	n.a.	31	5	6	4	21	12	7	3	1
West Bengal	63	53	40	52	7	62	51	42	20	6
Other	32	31	14	17	3	26	22	20	9	4
Other	1	2	2	3	0	3	1	4	2	1
Total	**40**	**35**	**25**	**34**	**5**	**52**	**36**	**23**	**12**	**3**

Source: World Bank.
Note: n.a. = not available.

Table C.3 Power Consumption for Households with Electricity Connection

(kWh/month)

State or union territory	2000 Total	2004 Total	2010 Total	Rural	Urban	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Andaman and Nicobar Islands	77	94	104	86	129	3	33	64	92	117
Andhra Pradesh	61	56	68	56	99	39	52	62	69	99
Assam	43	55	47	44	58	27	37	43	57	66
Bihar	39	51	39	32	56	33	35	39	41	59
Chandigarh	106	98	178	140	187	50	60	57	129	199
Chhattisgarh	n.a.	57	64	51	115	37	59	77	106	135
Dadra and Nagar Haveli	35	36	52	44	72	26	38	60	79	67
Daman and Diu	43	53	78	36	136	46	31	91	62	98
Delhi	179	123	180	87	187	61	89	93	129	218
Goa	79	103	151	128	202	50	81	73	120	196
Gujarat	61	56	82	60	110	39	46	63	82	125
Haryana	68	69	111	72	188	41	51	62	79	188
Himachal Pradesh	66	75	117	114	150	84	98	111	114	136
Jharkhand	n.a.	42	51	33	84	29	38	41	55	121
Karnataka	50	45	56	37	86	30	33	43	59	101
Kerala	53	71	77	66	108	43	50	55	67	100
Lakshadweep	89	109	149	120	182	138	176	158	141	151
Madhya Pradesh	50	69	52	36	89	31	44	52	60	98
Maharashtra	66	70	83	50	119	40	47	52	72	135
Manipur	49	65	54	54	56	50	57	54	51	56
Meghalaya	52	59	70	63	94	53	59	61	77	106
Mizoram	52	71	63	49	77	32	42	47	62	85
Nagaland	24	27	48	48	48	38	37	43	48	55
Orissa	88	92	80	73	105	59	71	88	91	115
Pondicherry	70	87	143	91	167	36	61	81	107	184
Punjab	93	103	126	101	167	44	57	79	107	188
Rajasthan	61	55	72	56	107	46	51	56	75	118
Sikkim	30	24	40	36	65	19	22	37	44	50
Tamil Nadu	138	63	87	60	118	44	59	65	87	144
Tripura	37	42	41	35	63	23	31	35	44	72
Uttarakhand	n.a.	74	66	57	97	46	56	65	74	67
Uttar Pradesh	44	64	71	50	102	47	52	57	73	122
West Bengal	65	71	59	44	81	36	40	47	60	102
Other	20	22	26	25	27	23	19	21	25	31
Other	57	62	79	67	112	55	55	66	78	116
Total	**70**	**66**	**76**	**54**	**111**	**39**	**49**	**58**	**75**	**126**

Source: World Bank.
Note: n.a. = not available.

Table C.4 Percentage of Income Spent on Electricity for Households with Connection

State or union territory	*2000 Total*	*2004 Total*	*2010 Total*	*2010 Rural*	*2010 Urban*	*2010 Quintile 1*	*2010 Quintile 2*	*2010 Quintile 3*	*2010 Quintile 4*	*2010 Quintile 5*
Andaman and Nicobar Islands	2.0	2.2	2.6	2.4	2.9	1.0	1.1	2.4	2.9	2.6
Andhra Pradesh	2.8	3.7	3.2	3.1	3.2	3.5	3.4	3.4	3.1	2.7
Assam	2.2	2.7	3.2	3.2	3.1	3.0	3.2	3.5	3.2	2.7
Bihar	1.8	2.5	2.4	2.1	3.0	2.6	2.4	2.1	2.3	2.4
Chandigarh	3.0	3.5	4.7	5.4	4.5	4.0	4.9	3.4	5.3	4.6
Chhattisgarh	n.a.	3.4	3.1	3.0	3.6	2.9	3.2	3.4	3.1	3.1
Dadra and Nagar Haveli	1.7	2.2	3.2	2.9	3.7	2.7	3.0	3.4	3.6	3.1
Daman and Diu	2.4	3.4	3.9	3.2	4.9	4.1	4.1	4.1	3.6	3.9
Delhi	3.0	4.9	5.4	4.8	5.4	4.0	5.5	5.1	5.6	5.3
Goa	1.9	2.7	2.4	2.1	3.2	1.4	2.3	1.9	2.0	2.9
Gujarat	3.5	4.5	4.6	3.9	5.4	4.5	3.9	4.4	4.8	4.9
Haryana	4.0	4.8	4.0	3.6	4.8	5.3	3.9	4.1	3.9	3.9
Himachal Pradesh	1.4	1.9	2.3	2.3	2.2	2.7	2.7	2.4	2.4	2.0
Jharkhand	n.a.	1.7	1.9	1.8	2.2	2.0	1.9	1.7	2.0	2.0
Karnataka	2.4	3.1	2.6	2.3	3.1	2.4	2.3	2.5	2.8	3.1
Kerala	1.5	2.7	2.1	1.9	2.6	2.4	2.3	2.2	2.1	2.0
Lakshadweep	4.0	6.0	2.7	2.7	2.7	3.3	4.1	3.0	2.8	2.5
Madhya Pradesh	2.7	5.0	4.1	3.7	5.0	4.1	4.3	4.1	3.9	3.9
Maharashtra	2.6	3.7	4.0	3.5	4.6	4.0	3.9	3.9	4.1	4.2
Manipur	2.6	4.4	3.6	3.6	3.8	3.8	4.1	3.7	3.2	2.1
Meghalaya	1.6	2.1	3.1	3.0	3.1	2.9	3.0	2.9	3.2	3.3
Mizoram	1.3	1.9	1.5	1.5	1.5	1.7	1.8	1.5	1.6	1.4
Nagaland	1.0	1.2	1.6	1.6	1.6	1.3	1.7	1.5	1.7	1.4
Orissa	4.4	4.4	3.5	3.6	3.1	3.9	3.9	3.6	3.1	2.4
Pondicherry	1.6	1.5	1.4	1.0	1.6	3.6	1.2	1.3	1.2	1.5
Punjab	4.5	5.4	5.1	4.6	6.0	4.7	4.5	4.9	5.3	5.4
Rajasthan	3.1	4.5	4.4	3.9	5.5	4.3	4.2	4.2	4.7	4.6
Sikkim	1.3	1.3	1.2	1.0	2.1	0.8	0.9	1.0	1.1	1.5
Tamil Nadu	2.0	2.6	2.0	1.7	2.3	2.0	1.9	1.9	2.0	2.2
Tripura	1.6	2.4	1.9	1.8	2.3	1.7	1.9	1.8	1.9	2.1
Uttarakhand	n.a.	3.5	2.6	2.5	3.0	3.0	3.0	3.1	3.2	1.7
Uttar Pradesh	2.3	3.4	3.6	3.0	4.5	3.5	3.5	3.5	3.7	3.9
West Bengal	3.2	3.6	3.6	3.2	4.2	3.5	3.4	3.6	3.6	3.8
Other	0.9	1.0	1.6	1.5	1.8	2.2	1.5	1.5	1.6	1.5
Other	1.9	2.4	2.3	2.1	3.0	2.7	2.5	2.3	2.4	2.0
Total	**2.7**	**3.7**	**3.4**	**3.0**	**4.0**	**3.3**	**3.3**	**3.3**	**3.5**	**3.5**

Source: World Bank.
Note: n.a. = not available.

Table C.5 Electricity Spending as a Percentage of Household Energy Expenditures

State or union territory	2000 Total	2004 Total	2010 Total	2010 Rural	2010 Urban	2010 Quintile 1	2010 Quintile 2	2010 Quintile 3	2010 Quintile 4	2010 Quintile 5
Assam	9.4	10.7	16.8	14.7	31.6	7.3	11.6	20.4	26.7	33.6
Bihar	3.7	5.0	6.9	4.9	22.6	3.6	5.8	9.4	12.3	26.5
Chandigarh	42.8	45.7	53.3	52.1	53.6	32.1	29.2	26.2	48.2	57.0
Chhattisgarh	n.a.	20.4	24.3	21.5	37.7	18.1	25.5	28.7	32.8	42.1
Daman and Diu	33.2	57.5	45.9	39.9	54.1	39.9	42.4	44.4	42.0	49.7
Delhi	37.1	54.0	64.7	61.3	64.9	17.5	48.6	49.9	55.3	72.3
Gujarat	35.6	38.8	42.0	33.5	53.9	26.4	27.9	34.9	45.6	58.4
Haryana	34.7	44.1	38.7	33.9	48.6	29.6	29.5	32.8	36.8	47.8
Himachal Pradesh	20.8	21.7	28.2	27.2	36.8	28.0	25.7	25.1	26.2	32.9
Jharkhand	n.a.	8.3	12.3	8.0	28.6	5.5	10.3	11.5	21.8	34.4
Madhya Pradesh	20.0	34.6	27.9	21.6	47.0	21.2	22.6	27.0	32.5	51.9
Manipur	19.4	31.1	29.8	28.6	32.9	20.4	29.4	29.8	33.8	28.8
Meghalaya	13.9	18.2	25.2	22.5	37.8	20.8	21.8	22.3	27.2	41.1
Mizoram	14.2	19.9	15.2	10.8	20.7	6.4	9.4	12.1	15.6	21.9
Nagaland	11.8	17.0	19.0	18.6	19.8	13.8	20.1	16.4	19.6	20.6
Orissa	11.9	19.7	19.4	16.7	35.1	10.2	22.1	22.7	30.0	42.9
Punjab	39.0	50.3	43.4	38.4	51.8	34.5	29.8	35.5	40.9	54.1
Rajasthan	20.5	26.7	31.8	24.8	51.9	16.6	21.8	28.0	35.9	52.7
Sikkim	19.7	14.0	19.9	15.8	43.0	5.6	8.0	12.6	17.6	34.8
Tripura	12.4	19.3	18.5	16.4	27.3	10.3	17.4	17.0	19.6	30.3
Uttarakhand	n.a.	24.1	40.1	40.9	37.0	18.9	20.0	23.9	30.4	69.1
Uttar Pradesh	10.4	15.3	16.4	10.6	36.9	7.0	11.3	16.7	24.0	39.6
West Bengal	12.4	18.4	21.3	14.0	41.6	11.0	14.4	18.0	29.0	45.5
Other	5.0	8.3	12.5	10.3	19.7	9.2	9.9	9.3	14.0	16.3
Other	25.2	30.7	26.2	22.5	37.2	24.2	24.8	24.4	26.1	30.2

Source: World Bank.
Note: n.a. = not available.

APPENDIX D

Regression Analysis

Table D.1 Determinants of Household Access to Electricity in Rural India

profit estimates with sample selection

Selected explanatory variable	*Model 1*	*Model 2*	*Model 3*
Age of household head (years)	0.0001 (0.16)	0.0001 (0.23)	–0.0002 (–0.67)
Sex of head (1 = male, 0 = female)	–0.014 (–0.84)	–0.012 (–0.77)	–0.010 (–0.63)
Highest education of adult male in household (years)	0.012** (8.40)	0.012** (8.39)	0.011** (7.18)
Highest education of adult female in household (years)	0.016 ** (9.53)	0.016 (9.56)	0.014** (8.57)
Household size	–0.001 (–0.65)	–0.002 (–0.88)	0.008** (3.21)
Log household's landownership (acre)	0.010** (5.05)	0.010** (5.05)	0.006** (3.19)
Fuelwood price (Rs./kg)	0.018 (1.42)	0.018 (1.43)	0.017 (1.36)
Kerosene price (Rs./liter)	0.003 (1.34)	0.003 (1.35)	0.003 (1.31)
Liquefied petroleum gas price (Rs./kg)	0.002 (0.27)	0.002 (0.26)	0.003 (0.55)
Electricity price (Rs./kWh)	–0.084* (–1.74)	–0.084* (–1.72)	–0.061 (–1.23)
Average electricity availability in village (hours/day)	0.017** (7.64)	0.017** (7.66)	0.017** (7.96)
Log household per capita income (Rs./month)	—	–0.006 (–1.02)	—
Log household per capita expenditure (Rs./month)	—	—	0.108** (8.49)
Pseudo R^2	0.377	0.301	0.345
Number of observations	24,191	24,191	24,191

Source: India Human Development Survey 2005.
Note: Marginal effects are reported. Figures in parentheses are *t* statistics based on robust standard errors clustered at the village level. Regression includes additional control variables at the household and village levels, including households' various nonland possessions, village infrastructure, and wage and consumer price variables. In addition, state-level dummy variables are used to control for any state-level unobservable characteristics that may influence household access to electricity; * and ** refer to significance levels of 10 percent and 5 percent, respectively. — = not available.

APPENDIX E

RGGVY Fund Allocations

State	Projects (no.)	Originally approved project cost (Rs. million)	Revised project cost (Rs. million)	Extent of revisions (%)	Amount disbursed (Rs. million)	Amount disbursed as share of revised cost (%)
Andhra Pradesh	26	8,405	8,988	7	8,002	89
Assam	23	16,600	27,610	66	24,137	87
Bihar	43	29,759	44,920	51	38,735	86
Chhattisgarh	16	11,391	11,681	3	8,103	69
Gujarat	25	3,604	3,955	10	2,870	73
Haryana	18	1,974	2,080	5	1,778	85
Himachal Pradesh	12	2,053	3,410	66	2,906	85
Jharkhand	22	26,626	34,683	30	30,616	88
Karnataka	25	6,001	8,919	49	7,417	83
Kerala	7	1,343	1,328	–1	937	71
Madhya Pradesh	32	15,334	18,933	23	14,606	77
Maharashtra	34	7,134	8,161	14	5,849	72
Manipur	9	3,578	3,818	7	2,972	78
Meghalaya	7	2,904	4,420	52	3,833	87
Mizoram	8	1,043	2,680	157	2,382	89
Nagaland	11	1,112	2,697	143	2,267	84
Orissa	32	36,151	38,109	5	33,087	87
Punjab	17	1,546	1,839	19	599	33
Rajasthan	40	12,545	13,390	7	11,038	82
Sikkim	4	571	1,965	244	1,729	88
Tamil Nadu	26	4,474	4,474	0	3,173	71
Tripura	4	1,315	1,973	50	1,757	89
Uttar Pradesh	64	27,195	37,913	39	34,010	90
Uttarakhand	13	6,439	7,601	18	6,858	90
West Bengal	28	23,446	27,482	17	22,776	83
Other	16	5,377	9,754	81	7,378	76
Other	14	6,359	9,332	47	7,841	84
India	**576**	**26,428**	**34,176**	**29**	**28,766**	**84**

Source: Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) Management Information System Report January 2013 (http://rggvy.gov.in/rggvy/rggvyportal/index.html).

APPENDIX F

RGGVY Processes, Institutional Roles, and Field Practices

	Responsible institution					
Process/activity	*REC*	*State government*	*Utility*	*Panchayat*	*CPSU*	*Field practice*
Rural electrification plan		Yes	Yes	Yes		Comprehensive rural electrification plans were developed and published by various states after 2007; involvement of panchayat officials was minimal.
Detailed project reports and plans for RGGVY	Yes	Yes	Yes	Yes		Needs-based specific projects were quickly identified. Planning was carried out based on either secondary data or through walk-through surveys. Involvement of panchayat officials occurred in only a few states. Panchayats provided the list of BPL households. In some cases, the list dated back to 2001 census data.
Project plan revision	Yes		Yes			Most states had to revise costing, mainly because of inappropriate initial planning.
Project approval	Yes					Where extent of deviation was greater than 20 percent, approvals were to be carried out by the Ministry of Power. Multiple iterations led to delays.
Loan agreement	Yes	Yes	Yes			Tripartite agreement is duly signed.
Project awards	Yes		Yes		Yes	Direct contracting of CPSUs by the REC for eight states and selected projects.
Material audit			Yes		Yes	Quality check and approval by the utility created unnecessary delays in some states.
Project implementation			Yes		Yes	Time overruns were quite common; in some cases, there were high-cost implications, which were borne by the utility.
Monitoring	Yes		Yes	Yes		On projects contracted out to the CPSUs, utilities have not conducted monitoring. Sample check on household electrification depended heavily on third-party inspection. Panchayat certification was secured for village electrification.

Source: PricewaterhouseCoopers 2012.
Note: BPL = below poverty line; CPSU = Central Public Sector Utility; REC = Rural Electrification Corporation; RGGVY = Rajiv Gandhi Grameen Vidyutikaran Yojana.

APPENDIX G

RGGVY Quality Review Process

The Ministry of Power (MOP) has established a third-party, quality-assurance process for approval and acceptance of projects implemented under the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) program scheme.[1] Operations are organized into three tiers:

- Tier 1 involves a third-party audit through a third-party inspection agency (TPIA) engaged by the Project Implementing Agency (PIA); the audit covers a randomly selected sample of 50 percent of villages under the project to ensure that all materials are utilized and workmanship conforms to the prescribed specifications.
- Tier 2 involves TPIAs, called Rural Electrification Corporation (REC) Quality Monitors, engaged by the REC; the audit covers a randomly selected sample of 10 percent of villages under the project to ensure that all materials are utilized, workmanship conforms to the prescribed specifications, and a preshipment quality check of major materials is completed at the vendors' outlets.
- Tier 3 involves TPIAs, called National Quality Monitors, engaged by the MOP; the audit covers a randomly selected sample of 1 percent of villages under the project.

Despite the quality-assurance process in place, recent studies have highlighted that some villages recorded under the RGGVY scheme as being electrified were still without access (Greenpeace India Society 2011a, 2011b; IDE 2012). These reports provide grassroots-level evidence of the quality-assurance mechanism's inadequacy. In light of these findings, Greenpeace recommended incorporating a social-audit mechanism into the final layer of verification and inspection of project completion.

Note

1. Notified by the MOP as Annexure-I of File No 44/37/07-D(RE) dated February 6, 2008, and incorporated into the REC's Quality Control Manual dated April 7, 2008.

APPENDIX H

Study Method to Calculate Cost of Rural Supply

To estimate the financial burden on states from rural service delivery, this study developed a method to calculate the cost of rural supply and the gap between per unit cost and revenue earned from rural areas. Cost of supply refers to the cost of delivering one unit of electricity to the end-user consumer (that is, rural household consumer). The average cost of supply is calculated for a state's overall consumer base, based on the values approved by the State Electricity Regulatory Commission (SERC) in the various Annual Revenue Requirement (ARR) orders.

To analyze how much revenue is recovered from consumers and the uncovered cost gap, the per unit revenue assessed for a rural household consumer at the average rural domestic tariff is also calculated. The per unit revenue is then subtracted from the per unit cost to obtain the uncovered gap per unit of electricity. This gap is either borne by the state government as subsidy support, appears on the utility's books as financial losses, or is borne by other consumers as a cross-subsidy.

Data Sources

The data sources used are the ARR and tariff orders issued by the respective SERCs for FY 2010/11.

Assumptions

- The rural cost of supply is more than the average cost of supply primarily because rural consumers are supplied through long low-tension (LT) lines, and transmission and distribution losses (T&D losses) for rural consumers are higher than losses for other consumer categories.
- For simplicity, it is assumed that other cost elements (for example, power purchase and operation and maintenance) for rural consumers are the same as for other consumers.

- The overall T&D loss of the utility comprises losses on high-tension (HT) and LT consumers. The T&D loss for HT consumers is assumed to be 5 percent. The balance of losses for the utility is attributable to LT consumers. The T&D loss for rural consumers is assumed to be the same as the balance of LT losses. The average revenue for rural consumers is assumed to be the average tariff rate for the utility's domestic consumers, who use 0–100 kilowatt-hour per month.

Formula

The average cost of supply (Av. CoS) for a distribution utility or state is calculated using the following equation:

$$\text{Av. CoS} = (\text{total ARR})/\text{total units billed or sold.}$$

ARR and units billed are the values approved in the last ARR and tariff order issued by the respective SERC.

The total sales approved by SERC are categorized into HT and LT sales. Then, the T&D losses for rural consumers are calculated as follows:

$$\text{Overall T\&D losses (units)} = \text{total units billed} \times \text{overall T\&D losses (\%)}/(100 - \text{overall T\&D losses (\%)})$$

$$\text{HT losses (units)} = \text{total sales to HT consumers} \times 5/(100 - 5)$$
$$\{\text{as specified above, HT loss is assumed at 5 percent}\}$$

$$\text{LT losses (units)} = \text{overall T\&D losses (units)} - \text{HT losses (units)}$$

$$\text{LT losses (\%)} = \text{LT losses (units)}/(\text{LT losses (units)} + \text{Sales to LT consumers})$$

The calculated cost of rural supply is expressed as follows:

$$\text{Cost of rural service} = \text{Av. CoS} \times (100 - \text{overall T\&D losses (\%)})/(100 - \text{LT losses (\%)})$$

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Achieving universal access to electricity by 2030 is not financially prohibitive for India. The challenge of providing electricity for all is achievable, ensuring that India joins such countries as China and Brazil in reaching out to even its remotest populations. Policies will need to be aligned with the principles followed in other successful international programs.

The potential benefits of electrification for those without service are quite high. The benefits of lighting alone would approximately equal the investments necessary to extend electricity for all. Households with electricity consume more than 100 times as much light as do households with kerosene for about the same amount of money. Without quality energy services, households often face entrenched poverty, poor delivery of social services, and limited opportunities for women and girls.

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