BANGLADESH

Beyond Connections

Energy Access Diagnostic Report
Based on the Multi-Tier Framework

ESMAP

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MTF Multi-Tier FRAMEWORK

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November 2019

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This Energy Access Diagnostic Report details the results of the MTF survey in Bangladesh and provides an informed account of the status of both access to electricity and access to modern cooking solutions in the country. This initiative has relied on the critical support of multiple entities and individuals that the MTF team would like to acknowledge.

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ABBREVIATIONS

ESMAP	Energy Sector Management Assistance Program
ICS	improved cookstove
IDCOL	Infrastructure Development Company Limited
IPS	instant power supply
km	kilometer
kV	kilovolt
kW	kilowatt
kWh	kilowatt hour
LPG	liquefied petroleum gas
MTF	Multi-Tier Framework
MW	megawatt
PNG	piped natural gas
SDG	Sustainable Development Goal
SHS	solar home system
Tk	Bangladeshi Taka*
WTP	willingness-to-pay

* 1 USD =Tk 84.71 on December 31, 2017.

EXECUTIVE SUMMARY

The Energy Sector Management Assistance Program (ESMAP) in the World Bank, in consultation with multiple development partners, has developed the Multi-Tier Framework (MTF) to measure and monitor energy access in terms of attributes and tiers. The MTF defines energy access as one that is *adequate, available when needed, reliable, of good quality, affordable, legal, convenient, healthy, and safe for all required energy applications across households, productive enterprises, and community institutions*.

As part of the stock-taking exercise on measuring access using MTF, ESMAP has launched detailed data collection activities in 17 countries, including Bangladesh. Findings of this report are based on nationally representative data on access to electricity and cooking solutions.

ACCESS TO ELECTRICITY

Bangladesh has made substantial progress toward achieving universal access to electricity—the electrification rate was 32% in 2000, 55% in 2010, and 73% in 2015.[1] Findings from the MTF survey suggest that 88% of the households in the country had access to some form of electricity in 2017. The access is almost 100% in urban areas (almost all grid connections) and 82% in rural areas (73% grid and 9% off-grid). Among the off-grid households, 97% use solar home systems (SHSs), while the rest are users of rechargeable batteries. The access rate matches closely the share of MTF Tier 1+ households, which is 87.9% nationwide, 99.5% in urban areas, and 81.7% in rural areas.

MTF analysis shows that Tier 3 households constitute the largest share of all households—46% nationwide, 40% in rural areas, and 59% in urban areas. About 11% of the grid-connected households are in Tiers 4 and 5 (highest tiers), while only 11% of the off-grid households (mostly SHS) are in Tier 3, the highest attainable tier for SHSs.

A substantial share of the SHS households (34%) are in lower tiers (Tiers 0 and 1). Those who are in Tier 1 (30%) are constrained by low capacity, while those in Tier 0 (3.7%) suffer from inadequate daily availability; more specifically, during the day.

Within the grid-connected households, availability in the evening is the main concern, affecting about 70% of the rural households and 73% of the urban households. Reliability is the second-most serious issue in urban areas, while daily availability ranks second in rural areas. To deal with power outages, households use a range of backup sources. Flashlights are the most common backup source—50% of the grid-connected households in rural areas and

[1] Available from World Bank Data, "Access to electricity (% of population)," https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=BD.

46% in urban areas use them. The other major backup source is kerosene in rural areas and an instant power supply unit in urban areas. To tackle the availability issue, the Government of Bangladesh (GoB) is in the process of implementing a number of steps, including developing new generation plants, investing in renewable energy technology, diversifying fuel choices for electricity generation, and importing electricity from neighboring countries.

The quality of the energy services is a major concern in rural and urban areas of Bangladesh. To deal with reliability and quality issues, the GoB is investing in new transmission lines and substations in collaboration with international partners such as the World Bank and the Asian Development Bank. In addition, prepaid meters are being installed in the substations to lower system losses. This and many other improvements can be incorporated into what is called "smart grid technology," which is also under consideration.

Monthly electricity consumption from the grid is found to be reasonably high—231 kWh in the urban areas, 106 kWh in the rural areas, and 150 kWh nationwide. Electric bulbs are the most used electric appliances, followed by mobile phone chargers and fans. Other appliances that rank high among the electric appliances are TVs (color and black and white), indoor air coolers, and refrigerators.

Lack of access is probably not a long-term issue in Bangladesh, as universal access is expected to be achieved by 2021 under the government initiative called Vision 2021. Meanwhile, non-grid households in grid areas should be offered grid. A large share of these households (40%) have already applied for grid connection and are in process of acquiring it soon. While willingness-to-pay (WTP) for the grid is very high, for some households (14% of the non-grid households), the connection fee is a barrier, and about 4% find the monthly cost too expensive. For the latter group of households (who are mostly ultra-poor,)[2] subsidized or no-cost connection may be provided, along with a subsidy in tariff.

For most of the unelectrified households in off-grid areas, adopting a SHS or connecting to a mini-grid (if available in the community) could be the solution. Many of the households who adopt SHSs use a microcredit-based financing scheme to pay for the system. However, for ultra-poor households who cannot afford the financing scheme, alternate solutions (for example, rental scheme such as pay-as-you-go) may be suitable.

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

Nationwide, the majority of the households use traditional stoves (58%), followed by clean cookstoves (35%), and improved cookstoves (ICSs) (over 6%). A large majority of cookstoves in the urban areas are clean cookstoves (73%), while in the rural areas traditional stoves are

[2] One way of defining ultra-poor is based on a food adequacy standard. If a person spends 80% or more of income on food, but he or she obtains 80 % or less of the average calorie requirements for his or her age, sex, and activity groups, that person (or household) could be defined as ultra-poor (Lipton 1988). In this report, the term *ultra-poor* is used more generally to refer to those who are the poorest.

most prevalent (77%). Over 8% of the main stoves in the rural areas are ICSs, while in the urban areas only about 3% households use an ICS as their main stove.

Despite a significant transition to cleaner fuels in recent times, firewood remains the most dominant cooking fuel in Bangladesh. Forty-six percent of the households nationwide, 58% in rural areas and 22% in urban areas, use firewood as their main fuel. A substantial share of households in rural areas (about 28%) also use other biomass fuels such as animal waste and crop residue. Clean fuel constitutes by far the largest share of cooking fuels used in urban areas (used by 73% of the urban households), while only 14% of the rural households use it. Among the clean fuels, liquefied petroleum gas (LPG) is more common in rural areas (used by 55% of the households), while piped natural gas (PNG) is more common in urban areas (used by 82% of the households).

Stove and fuel stacking are causes of concern, especially in rural areas. Fifty-five percent of the clean-stove users in rural areas also use biomass stoves, mostly traditional stoves, and only 10% of the clean cookstove users in urban areas are found to use biomass stoves. Nationwide, 75% of the households that use firewood use other biomass fuels, too. Crop residue is the most common biomass fuel stacked with firewood, followed by animal waste, and other inferior biomass fuels.

Based on the MTF, the majority of the urban households (62%) are in higher tiers (Tiers 4 and 5) and the majority of the rural households (75%) are in lower tiers (Tiers 0 and 1). While most ICS users are in Tier 2 (58.1%), a large share of them are still in Tier 1 (41.9%). Among the clean cookstove users, 75% are in Tiers 4 and 5, about 17% are in Tier 3, and remaining 8% are in lower tiers.

The main causes of concerns for cooking solutions in rural areas are the attributes Cooking Exposure, Convenience, and Efficiency. Things will improve if the households that use three-stone or traditional biomass stoves adopt ICSs. However, WTP for an ICS was found to be very low—79% of the households do not want to pay for an ICS. For ICS adoption in the rural areas, more promotion and sensitization activities are needed, along with better monitoring and after-sale service. For ultra-poor households, customized subsidy schemes may work.

The GoB has been making efforts to spread clean-cooking solutions using LPG. Increasingly, people are moving toward adoption of LPG cooking, including the urban population that now use mostly PNG for cooking. However, the LPG price is not regulated and does not often reflect the international price, something the government should consider. Also, more outlets and refill stations should be built, especially in the rural areas, to reduce price fluctuation and bring stability to the supply chain. Other areas of improvements may include lowering the practice of stove- and fuel stacking through campaigns and education and improving kitchen design, particularly improving the ventilation structure.

GENDER ANALYSIS

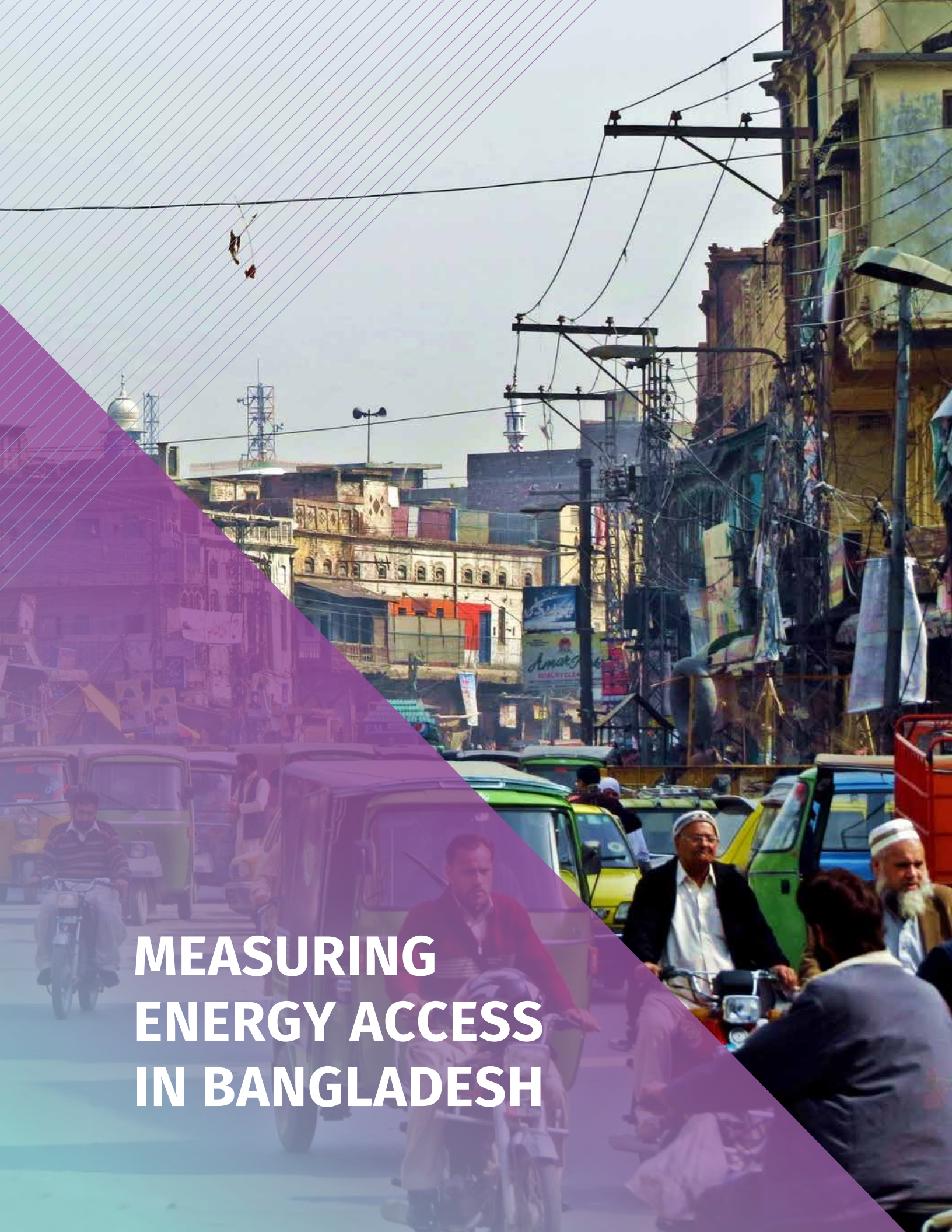
In Bangladesh, about 7% households are headed by women (6.5% in rural and 8.1% in urban areas). Female-headed households tend to be poorer than male-headed households—31% of the female-headed households and 23% of the male-headed households are in the bottom quintile.

Despite income differences, gender disparity in electricity access is low—there is only 1 percentage-point difference in household's grid connectivity by gender of the head. In addition, MTF tier distribution of electricity access does not vary much by the gender of the household head. The share of higher-tier households (Tiers 4–5) is about the same for male- and female-headed households (about 9%). Off-grid access is similar for both groups at the national level (at over 6%).

However, gender matters to cost of connection to grid electricity. Female-headed households mention more often than male-headed households that cost (connection and usage) is the main reason for not connecting to the grid. WTP analysis suggests, too, that female-headed households are less willing than male-headed households to buy an SHS unit at higher prices. Offering SHSs at subsidized prices or at low-interest financing may be a solution to the access problem of female-headed households.

Female-headed households have better access to clean cooking solutions—ownership of clean cookstoves is 40% among female-headed household and 34% among male-headed households. Female-headed households also do better in MTF tier distribution for cooking solutions. Thirty-two percent of female-headed households, as opposed to 25% of male-headed households, are in higher tiers (Tiers 4–5).

Better access to energy solutions may improve the quality of life for women, even though no causality between the two has been established. Women in grid-connected households spend more time in general than their counterparts in non-grid households in taking care of the children, helping children with studies, and listening to radio or watching TV. Women in grid-connected households also have more mobility. Women in households that use clean cookstoves spend much less time in fuel collection, fuel and stove preparation, and actual cooking than those in households who use traditional stoves or ICSs. For example, fuel collection time per day for women is only 5.1 minutes for clean cookstove users as opposed to 22.2 minutes for three-stone or traditional stove users. The former also report less incidence of coughing and eye irritation than the latter.



MEASURING ENERGY ACCESS IN BANGLADESH

MULTI-TIER FRAMEWORK (MTF): RATIONALE AND EVOLUTION

Access to modern energy is well recognized as a key factor in economic, social, and human development. It is one of the United Nations Sustainable Development Goals (SDGs).[3] However, given the specifics of these goals, the traditional binary definition of energy access (that is, whether or not a household has access) is no longer considered adequate to determining *effective* access.

Not all grid connections are created equal. While grid-connected households in developed countries enjoy exceptional service, many in the developing world suffer from unreliable and poor-quality supply, stemming from short duration, frequent outages, low or fluctuating voltage, and poor capacity. These constraints substantially lower the usefulness of grid access. Lumping all households under the rubric of "electrified" (a binary measure) misses all these details, which are critical to achieving the benefits of the electricity service. Second, demand-side issues such as affordability, legality of connection, and safety also prevent the households from reaping the full extent of electrification benefits. Third, technical advancement in recent years has made decentralized off-grid solutions (such as mini-grid and solar home systems, or SHSs) viable alternatives to the grid, particularly in rural and remote areas, and ignoring them is likely to underestimate the electricity access rate and its utility.

To address these issues, the Energy Sector Management Assistance Program (ESMAP), a global knowledge and technical assistance program in the World Bank, in consultation with multiple development partners,[4] has developed MTF to measure and monitor energy access in a more nuanced way.[5] This framework takes into account several aspects of the energy service, and transitions from the traditional binary definition of access to a multi-dimensional one as the ability to obtain energy that is adequate, available when needed, reliable, of good quality, affordable, legal, convenient, healthy, and safe for all required energy applications across households, productive enterprises, and community institutions. MTF is thus meant to improve our understanding of electricity access as well as identify bottlenecks that hold back households and institutions from benefitting fully from electricity access. And unlike a traditional approach, MTF considers off-grid sources as valid sources of electricity. For example, a solar lantern is not considered an electricity source in traditional measures, but, it can satisfy basic electricity needs to some extent for lower-income households without access to electricity.

[3] See Goal 7: Affordable and Clean Energy, http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-7-affordable-and-clean-energy.html.

[4] The development partners include organizations such as Gesellschaft für Internationale Zusammenarbeit (GIZ), Lighting Africa, Practical Action, Clean Cooking Alliance, the UN Development Programme (UNDP), the UN Industrial Development Organization (UNIDO), and the World Health Organization (WHO).

[5] MTF was introduced in the Global Tracking Framework (GTF) report (World Bank 2013).

The concept and development of MTF are similar to the trends observed in other socioeconomic fields—where multi-dimensional indicators have been developed, often alongside single-metric indicators. Examples of such indicators are Multidimensional Poverty Index and Energy Development Index. The development of such indicators is based on collective experience of the development practitioners and lessons learned over time.

COUNTRY CONTEXT

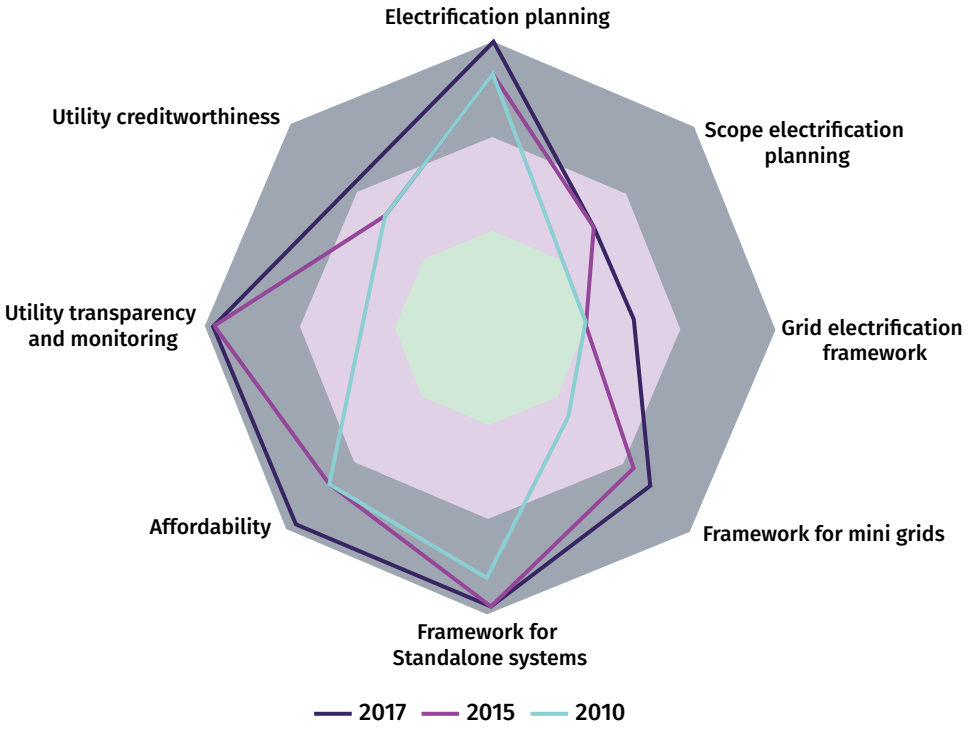
Located on the low-lying Ganges-Brahmaputra-Meghna Delta in South Asia—the largest delta in the world—Bangladesh is one of the most densely populated countries on the planet. The country shares its land borders with India and Myanmar and has a maritime border with the Bay of Bengal. It has a population of over 160 million (with 64% of its population living in rural areas) in a land of 57,000 square miles. Formerly a part of undivided India until 1947 and then of Pakistan, Bangladesh became an independent country in 1971.

Post-liberation, war-torn Bangladesh experienced one of the worst economies in the world; frequent flooding and subsequent recovery efforts negatively affected its economy, predominantly dependent on agriculture. However, Bangladesh's economy has grown at a rate of 6.5% since 2004. Currently the economy has been driven mostly by readymade garments export, remittances, and the agricultural sector.[6] The readymade garments sector leads the country's export market, followed by textiles, shipbuilding, fish and seafood, jute, and leather goods. Bangladesh has also developed self-sufficiency in pharmaceuticals, steel, and food-processing sectors. Bangladesh's telecommunication industry has also grown fast over time, resulting from large investments by international companies. Bangladesh has also been dubbed as one of the "Next Eleven" or N-11 countries by Goldman Sachs economist Jim O'Neill, who has described Bangladesh as having the potential to become among the world's largest economies in the 21st century (O'Neill and Stupnytska 2009). In 2015, Bangladesh transitioned from a lower-income country to a lower-middle-income country, and Bangladesh aspires to join the middle-income countries category by 2024.

Bangladesh has also made a remarkable progress in social sectors. Since 1990, the total fertility rate has fallen from 3.4 to 2.3, infant and maternal mortality rates have been reduced by half, and life expectancy has risen by 10 years to 69 (four years more than that in India in 2012). Bangladesh is also on target for achieving most of the Millennium Development Goals and is considerably ahead of the target on some indicators.

[6] After China, Bangladesh is the second largest garments exporter in the world.

FIGURE 1 • **Progress by indicator on electricity access, 2010, 2015, and 2017**



Source: World Bank 2018.

SECTOR CONTEXT: ELECTRICITY

Bangladesh has made remarkable progress in electricity coverage during past decade—the share of population with access to electricity has almost doubled since 2009, to over 90%, and is well set to achieve the 100% connectivity by 2021 as declared in the Vision 2021.[7] As a response to the increasing demand during the same period, generation capacity has almost quadrupled—from 4,900 MW to 20,000 MW (including 2,800 MW in captive generation)—and is expected to reach 24,000 MW by 2021. Consequently, the transmission line (400/230/132 kV lines) has grown from 8,000 circuit kilometers (km) to over 11,000 circuit km, and the distribution line from 260,000 km to over 450,000 km (Power Cell 2018). Distribution is handled by six organizations, which support more than 30 million customers.

About 41% of the generation is financed by private sector players—independent power producers, rental power plants, and quick rental power plants, and captive power plants. Until recently, natural gas has been the predominant fuel for generation; but other sources such as liquefied natural gas, coal, furnace oil, and diesel are being considered, besides importing power from India, Nepal, and Bhutan.

In rural areas, power distribution is handled by the Rural Electrification Board (REB), which operates through 80 cooperatives, called *Palli Bidyutayan Samity* (meaning rural electrification cooperative) or

[7] Vision 2021, a manifesto of the current ruling party, presents a framework for the future of the country and proposes a set of measures to achieve eight identified goals by 2021, the golden jubilee of the country.

more often simply PBS, serving about 24 million customers and over 300,000 irrigation pumps in 76,000 villages. The performance of REB is remarkable, with just 10% system loss and 99% bill recovery rate.

The government has a target of generating 10% of electricity demand from renewable energy sources by 2020. In Bangladesh, solar-based electrification is the most popular renewable energy solution source, especially in the remote areas. The SHS program of Bangladesh, promoted by Infrastructure Development Company Limited (IDCOL), is arguably the most well-known program of this kind in the world: 5 million SHSs have been disseminated under this government-financed program. Other solar-based initiatives run by the government include dissemination programs for both solar mini-grid and solar irrigation pumps. There are now 18 sponsor organizations under IDCOL's solar irrigation pump scheme, which have implemented over 600 irrigation pumps in rural areas. IDCOL has also financed 17 solar mini-grid projects in remote areas (mostly in river and sea islands) and has a target to finance 200 solar mini-grid projects by 2025.[8]

According to Regulatory Indicators for Sustainable Energy (RISE), Bangladesh has a comprehensive electricity access policy framework built on a strong foundation of electrification planning and has well-developed policies and regulations to bolster mini-grids and stand-alone systems. The policy apparatus includes mechanisms that make electricity affordable and utilities transparent and ensures quality supply. Bangladesh along with India, is a regional leader in RISE electricity access in 2017 (see Figure 1).

SECTOR CONTEXT: COOKING SOLUTIONS

About 70% of Bangladesh's population relies on solid fuel (biomass) for their cooking needs; unsurprisingly, the dependency is more substantial in rural areas. The chosen and dominating biomass fuel is firewood, which constitutes about 65% of all biomass consumption in the country, followed by crop residue (straw and rice husk, for example), animal waste, and dry leaves. The use of processed biomass such as pellets and briquettes is rare because they are more expensive.

Most rural households (and many in urban slums) that use biomass fuels cook in traditional mud stoves, while some use more primitive three-stone stoves. Improved cookstoves (ICSs), which have better thermal efficiency and are less polluting than traditional stoves, have been around for 30 years, but their usage has not really caught on. Recently, IDCOL has undertaken an ICS program with World Bank support based on the public-private partnership approach of the successful SHS program. This program has so far disseminated more than 1 million ICSs, with elaborate monitoring plan.

In Bangladesh, natural gas has been the clean fuel of choice in a number of urban areas, aided by substantial gas reserve of the country. However, the natural gas reserve has been shrinking, putting pressure on the country's energy needs. For some time now, approval for new residential gas connections has come to a halt because of depleted resources of natural gas; as a result, the government has been promoting liquefied petroleum gas (LPG) for residential use. Consequently, the use of LPG has grown immensely during the past 8 to 10 years. A large number of households in semi-urban and rural areas now use LPG stoves, sometimes

[8] From IDCOL internal document.

in combination with biomass stoves. Though currently there is no price subsidy on LPG connections or fuel refills in Bangladesh, it is a popular choice and method of fuel and cooking throughout the country. In rural areas, biogas is also used, although on a small scale. Finally, because of rapid electrification in recent years, some households have started using electric rice-cooker and induction cookstoves.

To help increase the adoption of clean cooking solutions, the Bangladesh Country Action Plan for Clean Cookstoves (CAP) was launched in 2013 by the Power Division of the Ministry of Power, Energy and Mineral Resources, with technical and financial inputs from the Clean Cooking Alliance (formerly, Global Alliance for Clean Cookstoves), SNV Netherlands Development Organization, GIZ Bangladesh, USAID, and the World Bank. CAP presents priority intervention options necessary to implement 100% adoption of clean cooking solutions in Bangladesh by 2030. Successful implementation of the priority interventions in this CAP is aligned to the government's priorities and will strongly contribute to the vision of smoke-free kitchens by 2030.

MEASURING ACCESS TO ELECTRICITY USING MTF

Acknowledging that electricity access is a spectrum of services, the MTF measures the extent of such services, resulting in an innovative narrative about electrification status. More specifically, MTF captures information on seven types of energy services, called attributes:

- ***Capacity*** ("What appliances can I power?"): The Capacity of the electricity supply (or peak capacity) is the ability of the system to provide a certain amount of electricity to operate various appliances, ranging from a few watts for light-emitting diode (LED) lights and mobile phone chargers to several thousand watts for space heaters or air conditioners. First, appliances are classified into tiers based on their power ratings (see table 1). Then, each household's appliance tier is determined by the highest tier of all its appliances; that is, if a household owns multiple appliances, the highest-capacity appliance determines the household tier. Capacity is measured in watts for grid, mini-grid, and fossil-fuel-based generators, and in watt-hours for rechargeable batteries, solar lanterns, solar lighting systems, and SHSs. It may be difficult to determine the Capacity attribute of the system by simple observation. An estimate of the available Capacity may be done based on the source of the supply (for example, grid is considered greater than 2,000 watts) or appliances used.

- ***Availability*** ("Is power available when I need it?"): The Availability of supply refers to the amount of time during which electricity is available. It is measured through two indicators: the total number of hours per day (24-hour period) and the number of evening hours (the 4 hours after sunset) during which electricity is available.

- ***Reliability*** ("Is my service frequently interrupted?"): The Reliability of electricity supply is a combination of the frequency and the duration of unexpected disruptions. In this report, the Reliability attribute is measured only for households connected to the grid.

- ***Quality*** ("Will voltage fluctuations damage my appliances?"): The Quality of the electricity supply refers to the absence of severe voltage fluctuations that can damage a household's appliances. Electric appliances generally require a certain level of voltage to operate properly. Low or fluctuating voltage can damage

BOX 1 • MTF TIERS FOR ELECTRICITY ACCESS AND MINIMUM REQUIREMENTS

Tier 0	Tier 1	Tier 2
Electricity is not available or is available for less than 4 hours per day (or less than 1 hour per evening). Households cope with the situation by using candles, kerosene lamps, or dry-cell-battery-powered devices (flashlight or radio).	At least 4 hours of electricity per day is available (including at least 1 hour per evening), and capacity is sufficient to power task lighting and phone charging or a radio. Sources that can be used to meet these requirements include solar lighting systems, solar home system (SHS), a mini-grid (a small-scale and isolated distribution network that provides electricity to local communities or a group of households), and the national grid.	At least 4 hours of electricity per day is available (including at least 2 hours per evening), and capacity is sufficient to power low-load appliances—such as multiple lights, a television, or a fan—as needed during that time. Sources that can be used to meet these requirements include rechargeable batteries, an SHS, a mini-grid, and the national grid.

Tier 3	Tier 4	Tier 5
At least 8 hours of electricity per day is available (including at least 3 hours per evening), and capacity is sufficient to power medium-load appliances—such as a refrigerator, freezer, food processor, water pump, rice cooker, or air cooler—as needed during that time. In addition, the household can afford a basic consumption package of 365 kWh per year. Sources that can be used to meet these requirements may include an SHS, a generator, a mini-grid, or the national grid.	At least 16 hours of electricity per day is available (including more than 3 hours per evening), and capacity is sufficient to power high-load appliances—such as a washing machine, iron, hair dryer, toaster, and microwave—as needed during that time. There are no frequent or long unscheduled interruptions, and the supply is safe. The grid connection is legal, and there are no voltage issues. Sources that can be used to meet these requirements include mini-grids or the national grid.	At least 23 hours of electricity per day is available (including 4 hours per evening), and capacity is sufficient to power very high–load appliances—such as an air conditioner, a space heater, a vacuum cleaner, or an electric cooker—as needed during that time. The most likely source for meeting these requirements is the national grid, though in theory it could be a generator or mini-grid as well.

Source: Bhatia and Angelou 2015.

TABLE 1 • **Power rating of electric appliances and corresponding tiers**

Power rating	Indicative electric appliances	Corresponding tier
Very low load (3–49w)	Task lighting, phone charging, radio	1
Low load (50–199w)	Multipoint general lighting, television, DVD player, computer, printer, fan, electric sewing machine	2
Medium load (200–799w)	Air cooler, refrigerator, freezer, food processor, water pump, rice cooker	3
High load (800–1,999w)	Washing machine, iron, hair dryer, toaster, microwave, electric kettle	4
Very high load (2000w or higher)	Air conditioner, space heater, vacuum cleaner, water heater, electric cookstove	5

Source: Bhatia and Angelou 2015.
Note: The list is by no means comprehensive but shows appliances that are most common. Tier calculation should consider all appliances that households use in the country in question, which in may not be covered by this list.

appliances, and even result in electrical fires. A low or fluctuating voltage supply tends to result from an overloaded distribution system or from long-distance low-tension cables connecting dispersed households to a singular grid. The MTF survey does not measure voltage fluctuation directly but uses incidents of appliance damage as proxy. In this report, the Quality attribute is measured for households connected to the grid only.

- ***Affordability*** ("Can I afford to purchase the minimum amount of electricity?"): The Affordability of the electricity service is determined by comparing the price of a standard electricity service package (1 kilowatt-hour [kWh] of electricity per day or 365 kWh per year) with household expenditure. The price of the package is determined from the prevailing lifeline tariff. If the package costs more than 5% of the household expenditure on electricity, then electricity service is considered unaffordable for that household.

- ***Formality*** ("Is grid electricity provided through a formal connection?"): The Formality of the grid connection is important, since it ensures that the electricity authority gets paid for the services it provides, besides providing for the safety of electric lines. A grid connection is considered formal when the bill is paid to the utility, a prepaid card seller, or an authorized representative. Informal connections pose a significant safety risk and also affect the financial sustainability of the utility. Reporting on the Formality of a connection is challenging. Households may be sensitive about disclosing such information in a survey. The MTF survey, thus, infers information on Formality from indirect questions that respondents may be more willing to answer, such as what method a household uses to pay the electricity bill. If households use the electricity service from the grid, but do not pay anyone for the consumption, their connection is assumed an informal connection.

- ***Health and Safety*** ("Is it safe to use my electricity service?"): This attribute refers to any injuries to household members from using electricity service from the grid during the preceding 12 months of the survey. "Injury" could mean limb injury or even death from burn or electrocution. Such injuries can result not just from faulty internal wiring (exposed bare wire, for example) but also

from incorrect use of electrical appliances or negligence. The MTF analysis, however, does not make a distinction between the two. Electricity access is considered safe when users have not suffered from past accidents from their electricity supply resulting in permanent injuries.

Each attribute, depending on the level of service a household receives from its main source of electricity, is assigned one of the six tiers—Tier 0 referring to the lowest level of service and Tier 5 the highest. Annex 1 gives a general definition of different tiers for each attribute.[9] The aggregate or final tier for a household is determined by the lowest tier across all attributes. Box 1 demonstrates typical scenarios in which households may be assigned different aggregate tiers. Grid households (or mini-grid households, if available) are the most likely candidates for Tier 5, while those without access to electricity are assigned Tier 0. In addition, households with electricity who do not get the service for required minimum hours during the day (4 hours) or the evening (1 hour) get Tier 0, so do those who have electricity but cannot even power light bulbs with capacity higher than 3w. It should be noted that certain attributes (Reliability, Quality, Affordability, Formality, and Health and Safety) do not apply to households if they do not have access to the grid or a mini-grid.

MEASURING ACCESS TO MODERN ENERGY COOKING SOLUTIONS USING MTF

Despite the well-documented benefits of access to clean cookstoves, around 3 billion of the world's population still use polluting and inefficient cooking solutions. The inefficient use of solid fuels has significant impacts on health, socioeconomic development, gender equality, education, and climate (Ekouevi and Tuntivate 2012; UNDP and WHO 2009; World Bank 2011). The consequences of inefficient energy use for cooking extend beyond direct health impacts. Such use also affects socioeconomic development; for example, fuel collection and cooking tasks are often carried out by women and girls. Collection time depends on the local availability of fuel and may reach up to several hours a day (ESMAP 2004; Gwavuya et al. 2012; Parikh 2011; Wang et al. 2013). The time spent on fuel collection and preparation often translates into lost opportunities for gaining education and increasing income (Blackden and Wodon 2006; Clancy, Skutch, and Batchelor 2003). In addition, the associated drudgery increases the risk of injury, and traveling far away may pose the risk of physical attacks (Rehfuess, Mehta, and Prüss-Üstün 2006).

The MTF measures access to modern energy cooking solutions based on six attributes: Cooking Exposure, Cookstove Efficiency, Convenience, Affordability, Health and Safety of primary cookstove, and Fuel Availability (see Annex 1).

- ***Cooking Exposure*** ("How is the user's respiratory health affected?"): This assesses the personal exposure to pollutants from cooking activities, which depends on stove emissions, ventilation structure, including cooking location and kitchen volume (see Annex 2). This attribute is a composite measurement of the emissions from the cooking activity, that is, the combination of the stove type and fuel, and mitigated by the ventilation in the cooking area. If a household

[9] Details of tier calculation are revisited when individual attributes are discussed.

BOX 2 • TYPOLOGY OF COOKSTOVES IN BANGLADESH

During the survey, the enumerators observed six types of cookstoves in Bangladesh.

1. ***Three-stone stove:*** It is characterized by open fire. Fuel rests on the ground.
2. ***Traditional biomass stove:*** It is made of mud. Fire is enclosed in the combustion chamber that is not fully insulated. Fuel rests on the ground.
3. ***Improved cookstove (ICS):*** Combustion chamber is well insulated and fuel rests on a shelf. It comes in different forms—some have a metal lining, some are equipped with a chimney, some are portable, and some are fixed to a location. It can be single- or double-mouthed.
4. ***Kerosene stove:*** It used to be common before people started using gas stoves, particularly in urban areas, but is rare now. The MTF survey found only seven households (about 0.1 % of the sample) using kerosene stoves as their main cookstoves. Given this, kerosene stoves are not included in this report's analysis.
5. ***Gas stove:*** It uses biogas (stove not shown here), natural gas, or LPG. It is considered a clean stove. LPG is more common in rural areas and its use has grown rapidly, while the majority of the urban population still use natural gas.
6. ***Electric stove:*** Most people use an induction type stove (almost exclusively in urban areas), and some use a rice cooker. It is considered the cleanest of all stove types.

PHOTO B2.1 • Stove types

1. Three-stone stove

2. Traditional biomass stove

3. Improved cookstove (ICS)

4. Kerosene stove

5. Gas stove

6. Electric stove

uses multiple stoves, the Cooking Exposure attribute is measured as a weighted average of the time each stove is used.

- ***Cookstove Efficiency*** ("How much fuel will a person need to use?"): Cookstove Efficiency is a combination of combustion efficiency and heat-transfer efficiency. Laboratory testing of the efficiency of various types of cookstoves informs the breakdown of efficiency levels by cookstove and fuel combinations, which can be observed in the field with relative ease.

- ***Convenience*** ("How long does it take to gather and prepare the fuel and stove before a person can cook?"): Convenience is measured by the amount of time a household spends collecting or purchasing fuel and preparing the fuel and the stove for cooking.

- ***Affordability*** ("Can a person afford to pay for both the stove and the fuel?"): Affordability assesses a household's ability to pay for both the cookstove and fuel. For this report, Affordability is measured using the levelized cost of the fuel. A cooking solution is considered affordable if a household spends less than 5% of total household expenditure on cooking fuel.

- ***Health and Safety*** ("Is it safe to use the stove?"): The degree of safety risk can vary by type of cookstove and fuel used. Risks may include exposure to hot surfaces, fire, or the potential for fuel splatter. Reported incidences of past injury or fire are used to measure safety.

- ***Fuel Availability*** ("Is the fuel available when a person needs it?"): The availability of a given fuel can affect the regularity of fuel use, while shortages in the fuel can cause households to resort to inferior secondary fuel types. This attribute assesses the availability of fuel as needed for a household's cooking purposes.

A methodology similar to the electricity framework is applied to obtain the aggregate tier for modern cooking solutions. The lowest tier among the attributes is taken as the final tier for the household (for more information on the threshold and tier calculation, see Annex 1.) Box 2 shows the typical cookstoves observed in Bangladesh.

USING THE MTF TO DRIVE POLICY AND INVESTMENT

Governments and policy makers can benefit from MTF findings in a number of ways. First, using MTF findings, countries can track progresses toward achieving their SDG 7 objectives and set targets for universal access based on existing status, budget, and other constraints. MTF analysis can also identify the barriers to achieving energy access goals, and the government and policy makers can revise their strategies accordingly. For example, given existing budget, governments can balance improving energy access for existing users (for example, reducing load shedding) and providing new connections. Moreover, since MTF analysis disaggregates findings by rural and urban areas, expenditure quintile, and gender of household heads, governments can take these factors into account while prioritizing their energy access goals.

Second, MTF recognizes off-grid solutions as sources of electricity. Households can reach Tier 5 access with mini-grid as they can with grid access and reach lower-tier access (Tiers 1–3) with low-cost solutions such as SHSs. Governments can expand electricity access to remote or isolated areas, where the grid will not go in foreseeable future, using SHS to meet households' basic electricity needs such as lighting, fans, radios, and TVs. As for cooking solutions, MTF analysis shows that, in most cases, ICSs can give a household up to Tier 3 access. Governments can thus promote ICS in rural areas where clean cooking solutions are not feasible for the time being.

Third, MTF analysis can better uncover the link between energy access and its benefits. For example, it is well established that electricity access has socioeconomic benefits. MTF analysis, by disaggregating access into different facets of electricity service, can identify which elements of the service (attributes) have the most impact. This helps governments and policy makers focus on those aspects of electricity service that need to be improved to enhance the benefits.

Finally, the MTF findings on willingness-to-pay analysis may provide inputs on how to price different access products (connection fee for grid access, price of solar home systems or improved cookstoves, for example). Given the available resources, the government can subsidize these components to ensure maximum access to energy.

MTF SURVEY IN BANGLADESH

The MTF survey in Bangladesh, undertaken by the government agency Power Cell, was based on a nationally representative sample (including rural and urban areas) of 4,500 households and was carried out during September–December 2017.[10] Geographically, the survey covered all eight of the country's divisions, the highest level of geographic administration. From each division one district was selected (the divisional district). One more district was randomly selected from the four largest divisions, making the number of total districts twelve. At the next stage, two or three *upazillas* (sub-districts) were selected from the districts, and then 375 enumeration areas (EAs) were sampled from the upazillas. Twelve households were then selected from each EAs, making the total sample of 4,500 households.

The indicator of interest, needed for sample size calculation, is the current grid-connectivity rate in the country, which is unknown. A 50% rate was assumed, which is the most conservative option possible as it gives the maximum sample size. A 5% margin of error was assumed, with the provision that reliable estimates by urban and rural areas are required. Finally, an allowance for a 10% non-response rate was considered. The sample selection was based on a multi-stage stratification strategy. In the first stage, City Corporations and two or three upazillas, including *sadar* upazillas (satellite upazillas for the district), from each of the twelve districts were selected. In the second stage, primary sampling units, which are EAs, were selected randomly. In the third stage, households from each selected EA were selected. MTF household survey sampling strategy aimed at keeping a 50:50 ratio between grid-electrified and non-grid households, and also a 50:50 ratio between urban and rural areas. While a

[10] The survey was physically carried out by the consulting firm Micro Industries Development Assistance and Services (MIDAS).

50:50 ratio was maintained for urban and rural household selection, this ratio could not be adhered to while selecting grid-connected and non-grid households because of the lack of adequate number of non-grid households in most EAs. Table 2 shows the distribution of sample households and Figure 2 shows the GPS coordinates of the sampled households in a map of Bangladesh.

Since the distribution of grid and non-grid households in the sample differs from that in the population, any findings derived directly from the data are expected to be biased. To adjust such biases, sampling weight was used in the analysis so that the findings are representative of the rural and urban areas, and at the national level.[11] Details of sample-size calculation are beyond the scope of this report, but suffice it to say that calculation of sample weight requires census data with rural-urban disaggregation, with an estimation of grid-connectivity status at the division level. Census data collected by Bangladesh Bureau of Statistics from 2011 was used to calculate the population projection for 2017 when the MTF survey was carried out. For those EAs selected in the first stage, the electrification status of households was obtained from the listing activity.

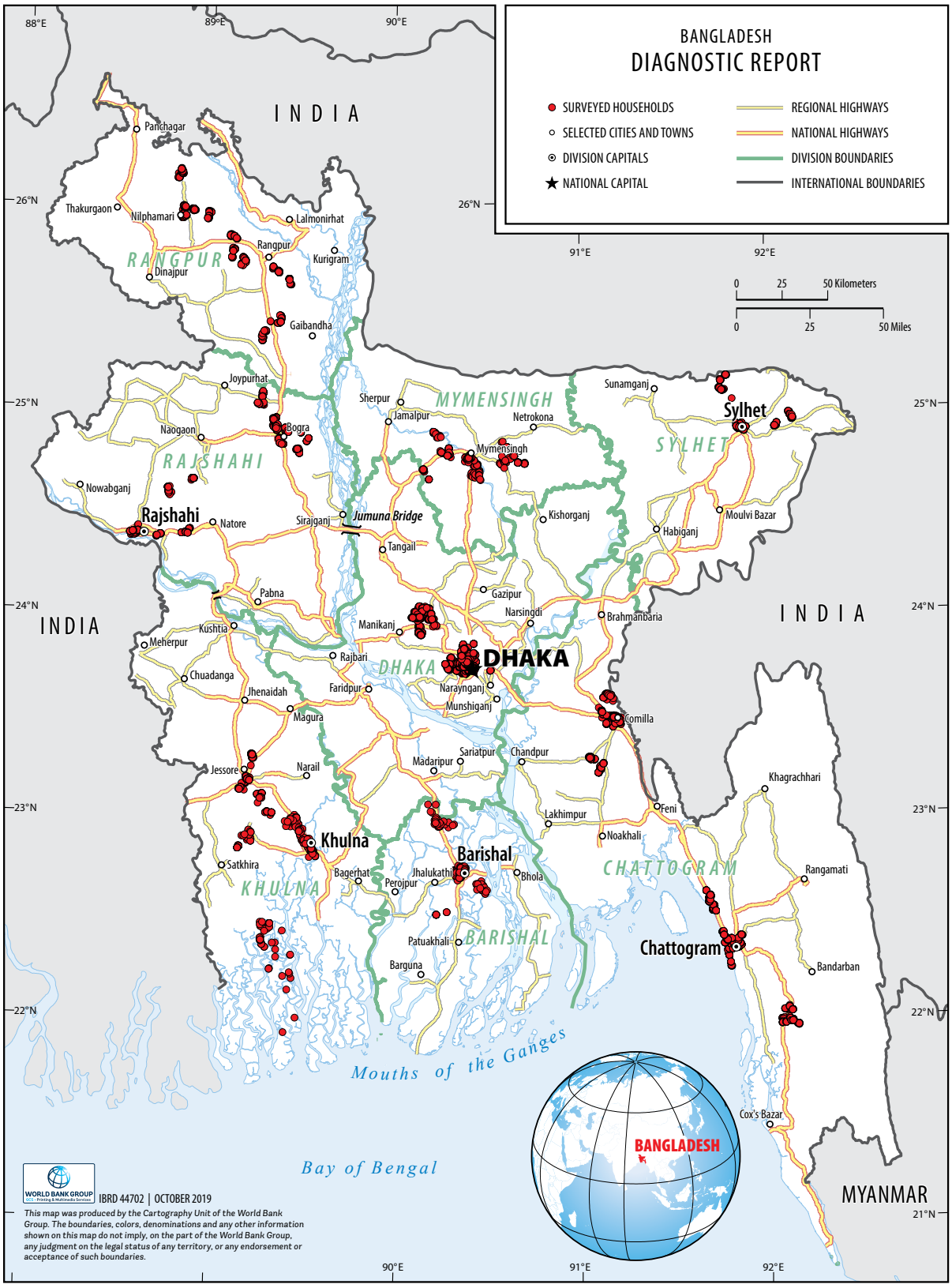
TABLE 2 • **Distribution of sampled households by grid access in the MTF survey, Bangladesh**

District	Total number of EAs	Urban areas		Rural areas	
		Grid HHs	Non-grid HHs	Grid HHs	Non-grid HHs
Dhaka	87	527	1	426	90
Chittagong	55	323	1	251	85
Comilla	39	240	0	166	62
Sylhet	25	144	0	92	64
Mymensingh	37	202	26	165	51
Rajshahi	19	105	3	73	47
Bogra	25	156	0	92	52
Rangpur	21	120	0	67	45
Nilphamari	13	84	0	48	24
Khulna	17	96	0	62	46
Jashore	20	119	1	48	72
Barishal	17	107	1	51	45
Total	**375**	**2,223**	**33**	**1,561**	**683**

Note: EA = enumeration area: HH = household.

[11] Sampling weight is an adjustment factor applied to each observation of the data to adjust for differential selection probability of the households and make the findings representative of the underlying population.

FIGURE 2 • **GPS coordinates of sampled households from MTF survey, Bangladesh**



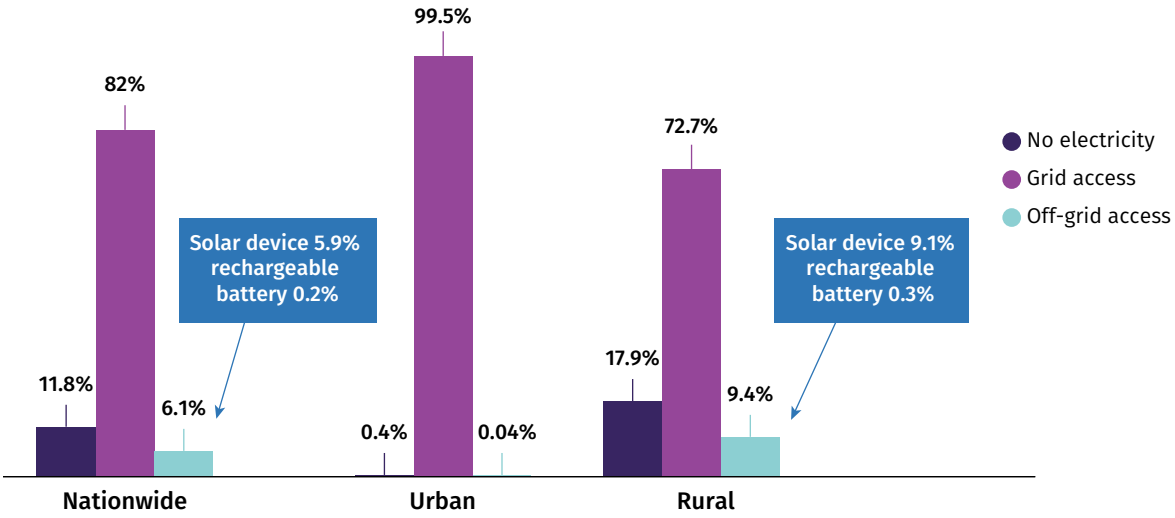
Source: MTF household survey 2017.

ACCESS TO ELECTRICITY

ASSESSING ACCESS TO ELECTRICITY

In Bangladesh, more than 88% of households have access to electricity via the national grid (82%) or off-grid sources (6.1%) (Figure 3). Grid electrification rate is about 73% in rural areas, almost 100% in urban areas, and 82% nationwide. This is a remarkable achievement given that electrification rate was just 55% in 2010.[12] This implies a growth of 4.7 percentage points per year during the past seven years. The off-grid source is overwhelmingly solar-based sources (about 97%), followed by rechargeable batteries (about 3% within the off-grid sources, or 0.2% overall). Among the solar-based sources, most prominent is the solar home system (SHS), while very few households use solar lanterns as their main source of electricity.[13] It is obvious that off-grid access is a completely rural phenomenon. About 5 million rooftop SHS units have been installed so far under Infrastructure Development Company Limited's (IDCOL's) SHS program.

FIGURE 3 • **Access to electricity by binary definition and technology (Urban, rural and nationwide)**

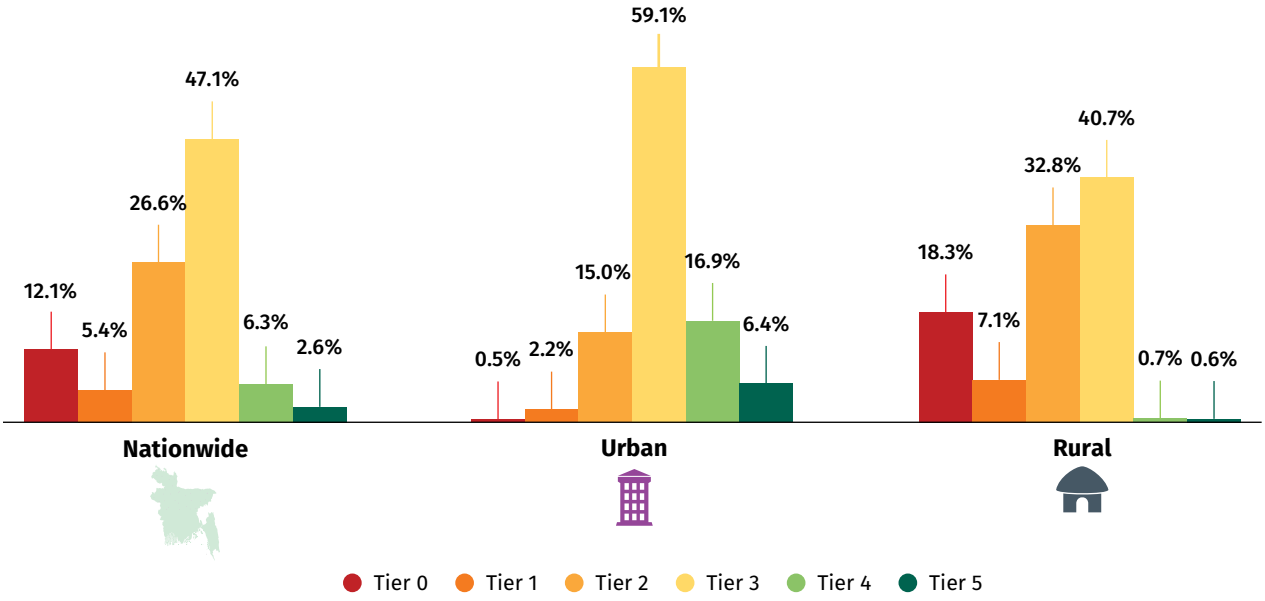


Source: MTF household survey 2017.

[12] See World Bank Data, "Access to electricity (% of population)," https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=BD.
[13] Besides the off-grid sources mentioned here, solar mini-grids are also used by a small share of rural households in Bangladesh; but they can be found only in a few isolated and remote locations and are not covered by the survey.

Based on MTF, households above Tier 0 are considered to have access to electricity. Accordingly, about 88% of households in Bangladesh are in Tier 1 or above, with about 82% in rural and almost 100% in urban areas. Tier 3 has the highest share of households—47% nationwide, 41% in rural areas, and 59% in urban areas. This means that these households most likely have grid access, have electricity service available at least 8 hours a day and 3 hours in the evening, and use medium- to high-load appliances.[14] There is a wide urban-rural disparity—only 1% of the rural households are in higher tiers (Tiers 4–5), compared to about 23% of the urban households. Moreover, lower tier households (Tiers 1–2) constitute about 25% of the rural households and only 3% of the urban households. Overall, only 2.6% of Bangladesh population have Tier-5 access. (Figure 4).

FIGURE 4 • **MTF Tier distribution: Access to electricity (urban, rural, and nationwide)**

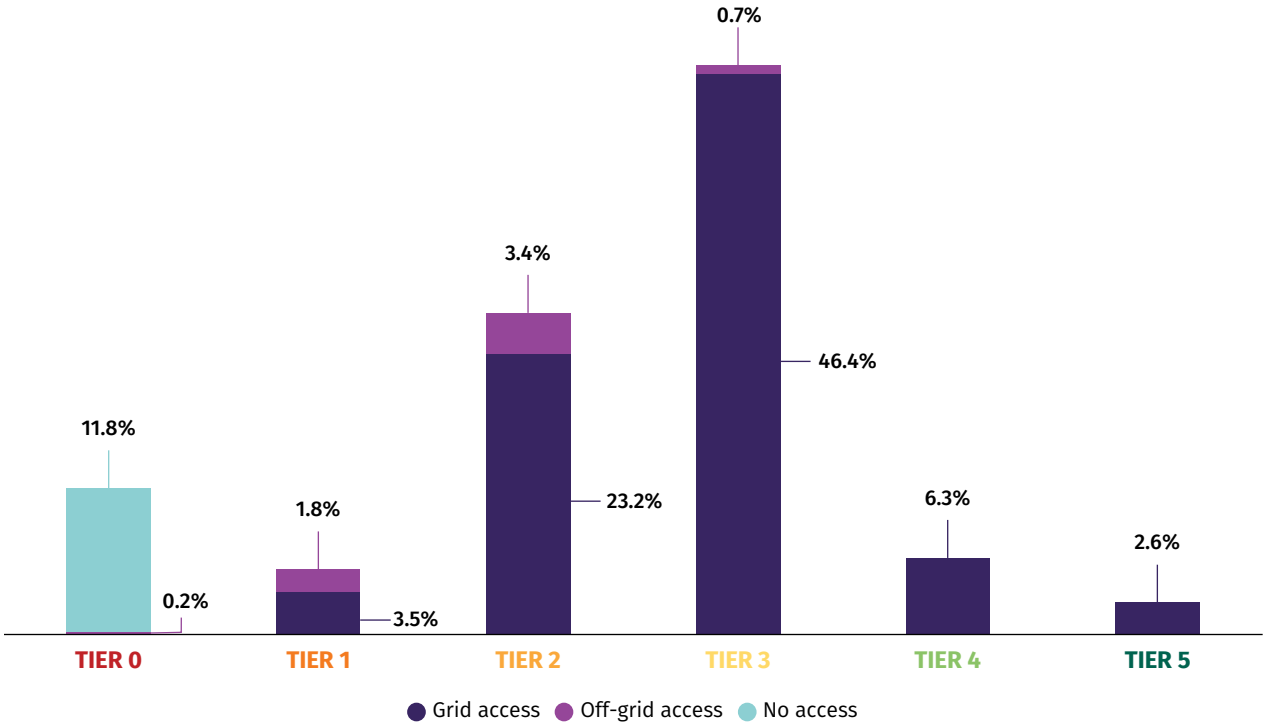


Source: MTF household survey 2017.

Households in Tiers 3–5 are almost all grid-connected, with only less than 1% comprising users of off-grid sources (in Tier 3) (figure 3). On the other hand, households in Tier 0 are mostly without any source of electricity, with the exception of a tiny fraction (0.2 %) who use off-grid sources of electricity. The reason why certain households with access are still in Tier 0 will be explored when individual attributes are discussed.

[14] Examples of medium- and higher-load appliances are refrigerators, rice cookers, iron, microwaves, and air conditioners. We cover appliance capacity in more details later.

FIGURE 5 • **MTF tier distribution by main sources of electricity**

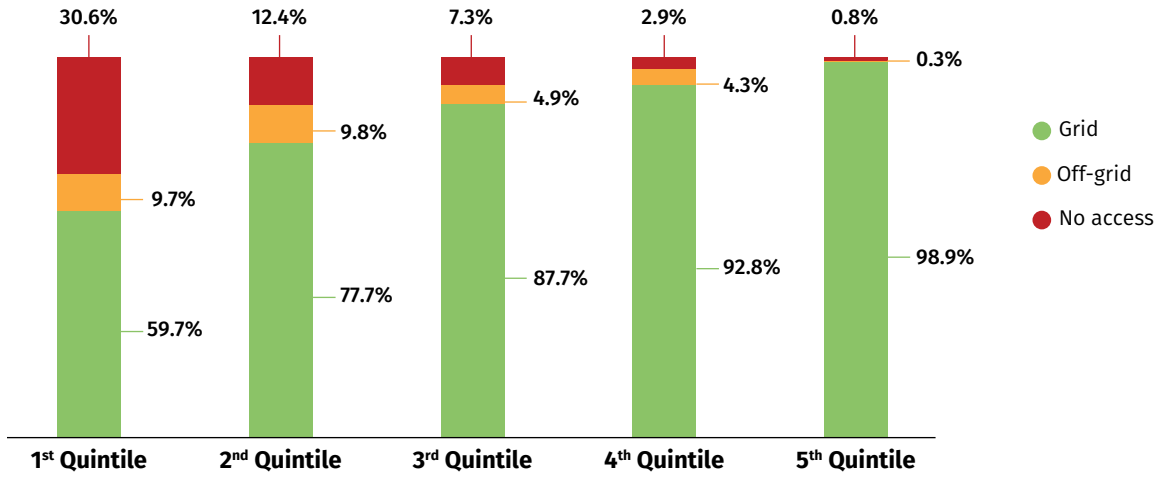


Note: Off-grid sources are mostly solar home systems. Other off-grid sources are negligible: 0.17% with rechargeable batteries and 0.02% with solar lanterns.
Source: MTF household survey 2017.

ELECTRICITY ACCESS BY HOUSEHOLD ECONOMIC STATUS

The relationship between energy access and household economic status is an important issue. Most infrastructure projects in the developing countries, such as electricity expansion, have poverty-alleviation goals, and their success is often measured by the extent of their coverage of low-quintile households. However, in reality, it is often the better-off households that connect first when grid is expanded to a community, and low-quintile households are usually late connectors to electricity. While higher-quintile households are more likely to be connected to grid, inter-quintile disparity is wide—grid access in the 1st and 5th quintiles is separated by almost 40 percentage points (Figure 6). More specifically, grid connectivity is 59.7% among the lowest quintile households, while it is 98.9% among the wealthiest households. The trend in off-grid connectivity (which means adoption of SHS in almost all cases) is, not surprisingly, opposite to that in grid-connectivity—off-grid connectivity is 9.7% among the lowest-quintile households and only 0.3% among the highest-quintile households. Since off-grid households are all rural, there is some disparity in access by expenditure quintile in rural areas, that is, poor households are more likely to use off-grid sources than wealthy households.

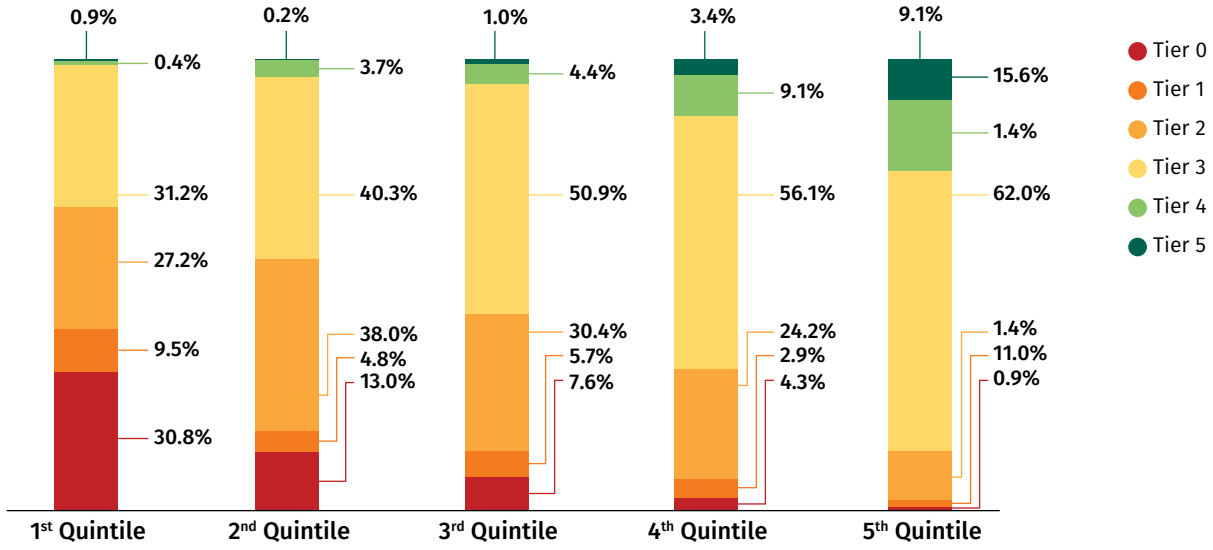
FIGURE 6 • **Main source of electricity by household expenditure quintile**



Source: MTF household survey 2017.

Households in the lowest quintile have the highest share of Tier 0 households (about 31%), while those in the top quintile have the lowest share of Tier 0 households (less than 1%) (Figure 7).

FIGURE 7 • **MTF tier distribution for electricity access by household expenditure quintiles**



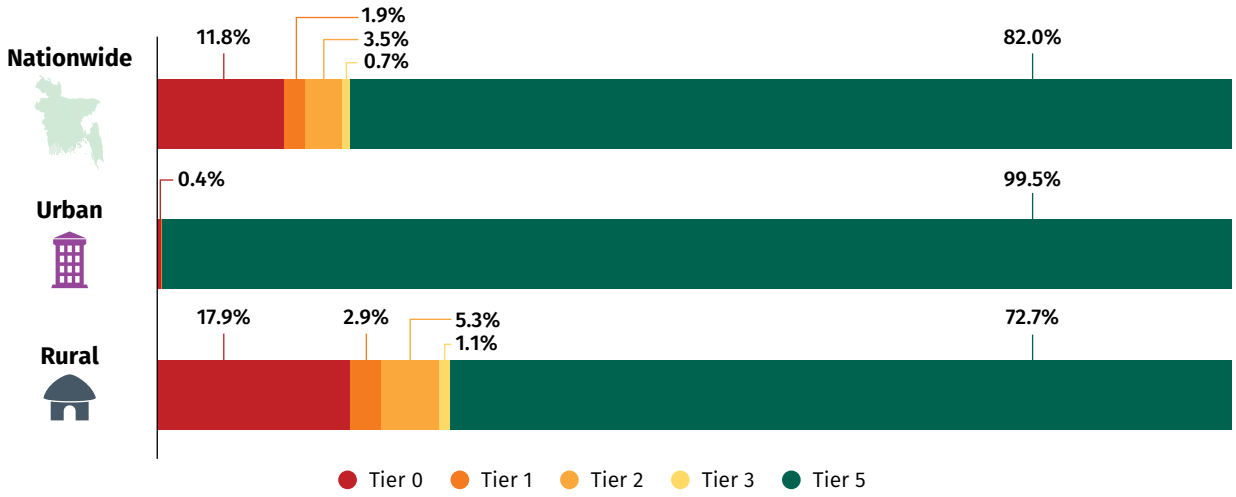
Source: MTF household survey 2017.

ANALYSIS OF MTF ATTRIBUTES FOR ELECTRICITY ACCESS

Capacity

The Capacity attribute represents the ability to provide a certain amount of electricity to power various appliances, ranging from a few watts for light-emitting diode (LED) lights and mobile phone chargers to several thousand watts for space heaters or air conditioners. All grid-connected households are considered to have high-capacity electricity (over 2 kW), and consequently assigned a tier value of 5. Similarly, households using mini-grids are assumed to have high-capacity electricity unless the use of appliances is constrained by the capacity limit imposed by the supplier. Households using SHS are assigned tiers based on their appliances. Overall, 82.0% of the households are in Tier 5, and 11.8% are in Tier 0 (Figure 8).

FIGURE 8 • **Distribution of households based on the Capacity attribute (urban, rural, and nationwide)**



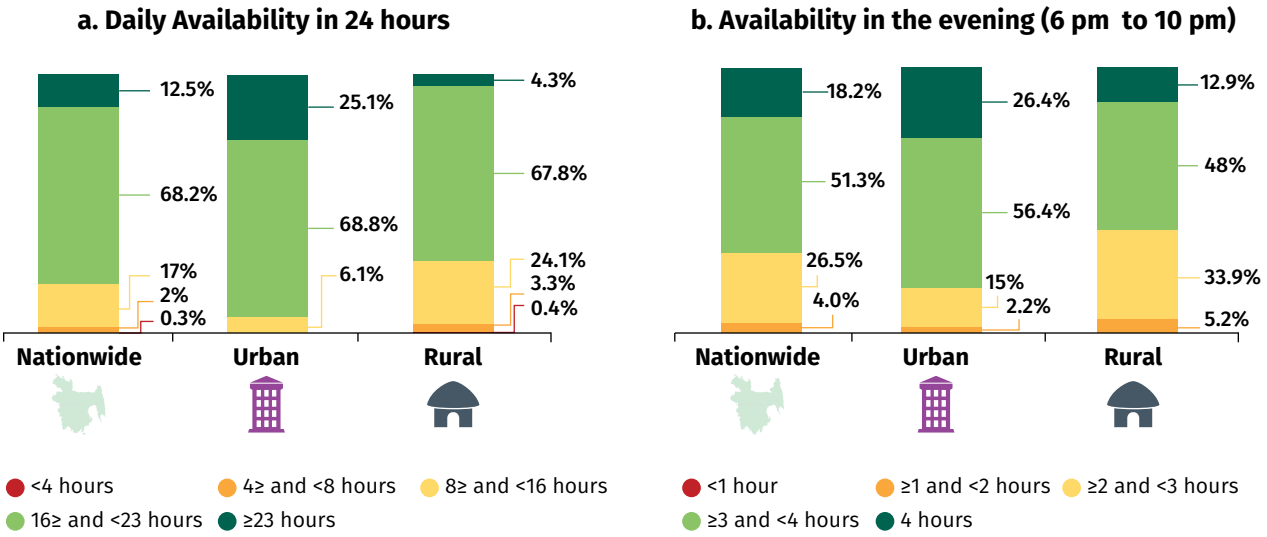
Source: MTF household survey 2017.

Availability

The Availability attribute consists of two components: daily (24 hours) and evening availability (4 hours between 6 pm and 10 pm). Nationwide, about 80% of the household with electricity access enjoy at least 16 hours of service a day, and among the urban and rural households the share of such households is 94% and 72%, respectively. When it comes to having full-time service, rural and urban households vary quite a lot—one quarter of the urban households get electricity service for 23 hours or more, while only 4% of the rural households enjoy the same availability. About 28% of the rural households do not get 16 hours of service per day, while the share of such households is only 6% in urban areas.[15] As for the evening Availability, over 80% of the urban households enjoy good hours of service (3–4 hours), whereas such service is available to 61% of the rural households with electricity (Figure 9).

[15] An extremely low share of grid-connected households in the urban areas (0.01%) do not get 4 hours of electricity per day and are subsequently relegated to Tier 0.

FIGURE 9 • **Distribution of households based on Availability**

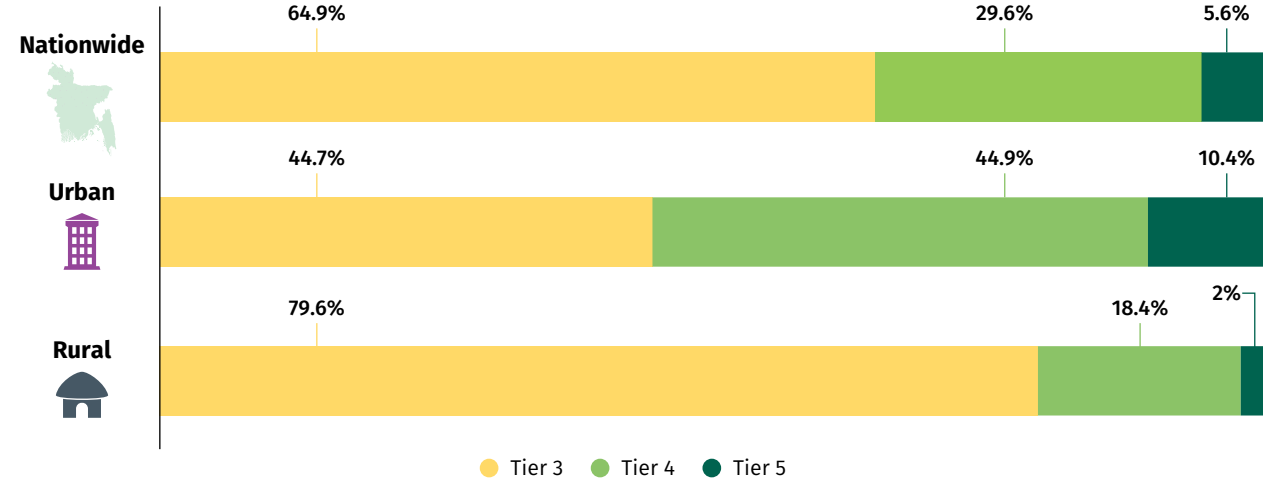


Source: MTF household survey 2017.

Reliability

The Reliability attribute captures the frequency and duration of unscheduled outages,[16] and it applies only to grid-connected households. Reliability is a critical issue in the electricity service in Bangladesh. A majority of the grid-connected households (65%) report more than 14 outages per week. While the share of such households is less than 50% for urban households, it is a whopping 80% for the rural households. Nationwide less than 6% of the households report high reliability—three or fewer outages per week, while 10% of the urban and only 2% of the rural households enjoy such reliable electric services (Figure 10).

FIGURE 10 • **Distribution of households based on Reliability (urban, rural, and nationwide)**



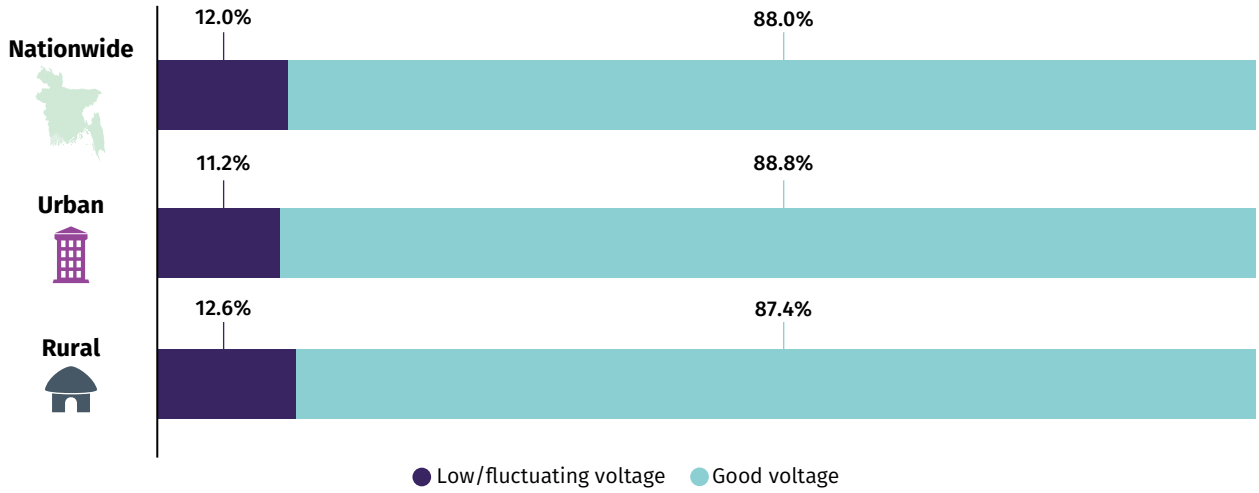
Source: MTF household survey 2017.

[16] In constructing the Reliability tier, with regards to the Reliability tier, only frequency of outages was considered, unlike the specification of Annex 1.

Quality

The Quality attribute applies only to households with the national grid. Electric appliances require a certain voltage supply to operate properly. A low or fluctuating voltage can damage appliances, and even worse, may result in electrical fires. A low or fluctuating voltage supply tends to result from an overloaded distribution system or from long-distance low-tension cables connecting dispersed households to a single grid. The MTF survey does not measure voltage fluctuations directly but uses incidents of appliance damage as proxy for voltage fluctuations. In Bangladesh, 12% of the grid-connected households face voltage issues, resulting in appliance damage (Figure 11). There is not much difference between urban and rural areas as far as voltage issues are concerned.

FIGURE 11 • **Distribution of households based on Quality (urban, rural, and nationwide)**



Source: MTF household survey 2017.

Affordability

Affordability is determined by comparing the price of a *standard electricity service package* with household expenditure,[17] where the standard service package is defined as the consumption of 1 kWh of electricity a day or 365 kWh/year.[18] In Bangladesh the lifeline tariff is Tk 3.50 or US$0.04 for all locations, and accordingly, the price of the basic electricity service is Tk 1,278 or US$16 a year. This is an extremely small amount even in the context of Bangladesh. Accordingly, electricity is affordable to all grid-connected households, and so, no chart is drawn to show the Affordability attribute.

Formality

Formality refers to a household grid connection that is provided and/or sanctioned by the authority. Thus, this attribute is only applicable to the grid-connected households. The MTF survey questionnaire

[17] Capturing income through survey questionnaire is often difficult because of its sensitive nature. The MTF calculation uses household consumption expenditure as proxy for income.

[18] It is important to note that this package includes only recurring costs of electricity consumption, not any fixed or one-time cost such as connection cost and cost for internal wiring.

does not ask directly about the Formality of the connection, as respondents may not be forthcoming. Instead, the respondents are asked whom they pay for the electricity use, and any response indicating a non-payment is inferred as having an informal connection. As table 3 shows, a very large share of electricity payments (93%) are made to the utility company, followed by a very small share of payments made to prepaid meter-card seller (2.7%). All in all, payments by all households are accounted for. Accordingly, the informal grid connection is not seen as an issue in Bangladesh.

TABLE 3 • **Distribution of grid households by recipients of electricity payment**

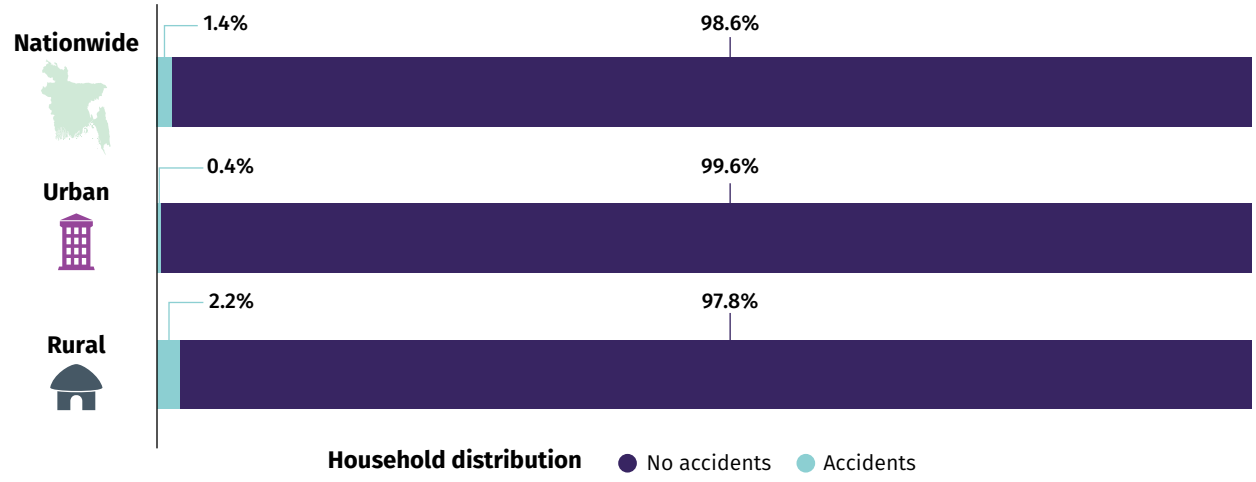
Recipients	Share (%)
Utility company	93.2
Prepaid meter card seller	2.7
Village or municipality	0.3
Relative	1.1
Neighbor	0.6
Landlord	2.0
Other	0.1

Source: MTF household survey 2017.

Health and Safety

The Health and Safety attribute refers to any injuries to household members from using electricity service from grid during the preceding 12 months of the survey. Injury could mean limb injury or even death from burn or electrocution. Such injuries can happen not just from faulty internal wiring (exposed bare wire, for example), but also from incorrect use of electric appliances or negligence. MTF analysis, however, does not make a distinction between the two. Incidents of injuries from electricity use are very low, affecting only 1.4% of the grid-connected households (Figure 12). While rural households are more likely to suffer from such injuries than urban households, safety is not an issue for the electricity users in Bangladesh.

FIGURE 12 • **Distribution of households based on Health and Safety (urban, rural, and nationwide)**

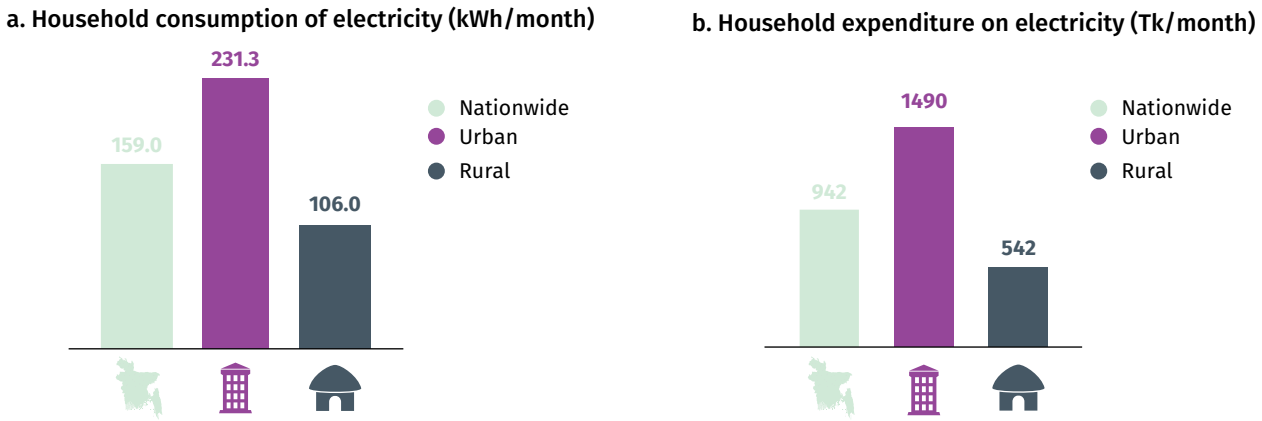


Source: MTF household survey 2017.

USE

Nationwide, households consume, on an average, 159 kWh of electricity per month and pay Tk 942 (or US$11) for such consumption.[19] There is a wide gap in consumption between rural and urban areas—households in rural and urban areas consume 106 kWh/month and 231 kWh/month, respectively (FIGURE 13 · Household consumption (kWh per month) of and expenditure (Tk per month) on grid electricityigure 13). These consumption figures are much higher than the basic consumption package considered in the discussion of Affordability attribute, which is about 30 kWh/month. The disparity also makes sense given that rural households, on an average, have been connected to grid only for less than 12 years, while urban households have been for more than 25 years. The consumption amount is consistent with the government estimate of per capita yearly generation of 464 kWh per year, which has more than doubled during last 8 years—a significant achievement (Power Cell 2018).

FIGURE 13 • **Household consumption (kWh per month) of and expenditure (Tk per month) on grid electricity**



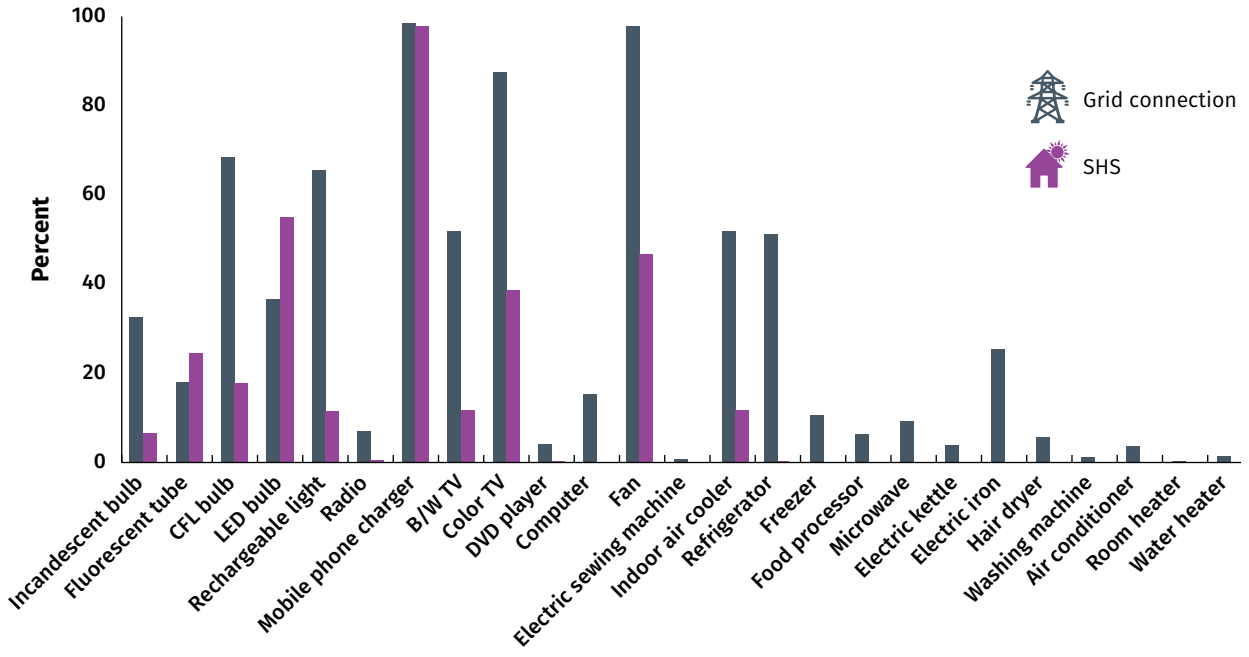
Source: MTF household survey 2017.

The mobile phone charger is the most used electric appliance regardless of the source of electricity—close to 100% of households have one. Other appliances that rank high among the grid-connected households are fans, color TVs, rechargeable lights, indoor air coolers, refrigerators, and different types of electric bulbs.[20] While compact fluorescent bulbs are most common among the grid-connected households, it is the LED bulbs that are mostly used by SHS users. It is obvious that SHS users do not use any of the medium- to high-capacity appliances as they are constrained by the limited capacity of the SHS unit (FIGURE 14 · Household appliance ownershipigure 14).

[19] While the actual expenditure on grid consumption is not used in the analysis of the MTF Affordability attribute, it is worthwhile to look at how actual grid electricity expenditure compares to a household's total expenditure. Results showed that expenditure on grid electricity is about 5% of the household's total consumption expenditure (3.4% in rural and 6.7% in urban areas). Because of the more diverse appliances used by urban households, they tend to spend more on electricity than the Affordability threshold, which is 5%.

[20] The electric bulb is the most used electric appliance when all types are combined, since lighting is the primary reason for adopting electricity. Combining light bulbs of all types, light bulbs are used by 100% of the households.

FIGURE 14 • **Household appliance ownership**



Source: MTF household survey 2017.

IMPROVING ELECTRICITY ACCESS

Giving electricity access to those without access

About 12% households do not have access to any source of electricity, and these are mostly from rural areas (FIGURE 3 • Access to electricity by binary definition and technology (nationwide, urban, and rural) igure 3). A large share of these households without access to the national grid (40%) are in process of getting grid connection soon, as they have already applied for it. About one-third of unelectrified households reported that the availability of grid infrastructure is a barrier. For 13.8% of the non-grid households, the connection fee is a barrier, and 3.8% of these households find the monthly cost too expensive (Figure 15).[21]

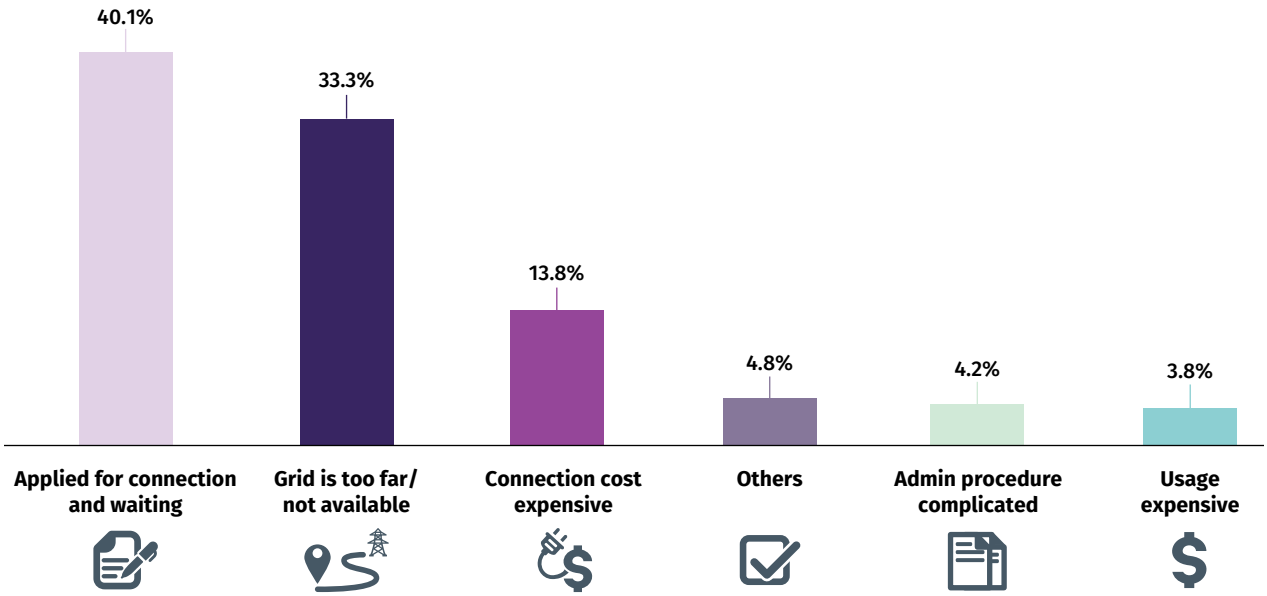
To investigate whether connection cost is a barrier, a willingness-to-pay (WTP) analysis has been carried out.[22] During the survey interviews, non-grid households were asked if they would adopt grid electricity if they were offered it at a certain price and certain payment plan, which were randomly selected from a range of prices and payment options to pay for the connection. WTP for grid is very high in Bangladesh:[23] an overwhelming share of households (97.8%) would like to connect to grid for

[21] This may seem contradictory to the finding from the analysis of the Affordability attribute, which shows that electricity service from grid is affordable to almost all households. One explanation for this could be that the aspirational consumption demand of electricity for these households must be higher than one kWh per day, the standard package considered for Affordability analysis.

[22] Cost for grid connection has been falling steadily—it was on an average Tk 2,800 (US$40) in 2005 and currently stands at only Tk 650 (US$8).

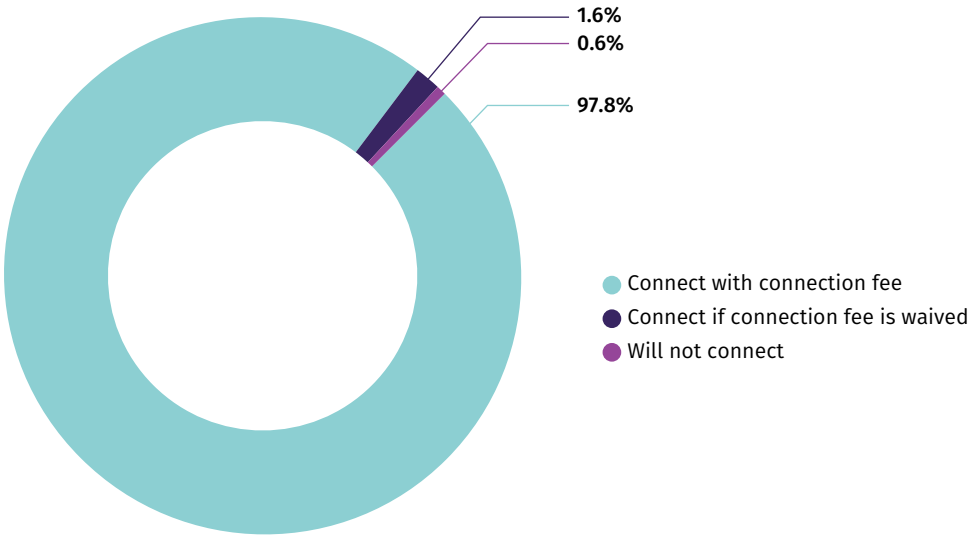
[23] Willingness to pay is not same as the ability (or capacity) to pay, because a potential customer may be able to afford to pay for a product or service but still decides not to do so. The reasons could be habitual, behavioral, and so on. In this analysis, it is assumed that willingness to pay takes into account the ability to pay.

FIGURE 15 • **Barriers to gaining access to grid electricity**



Source: MTF household survey 2017.

FIGURE 16 • **Household's willingness to connect to grid**



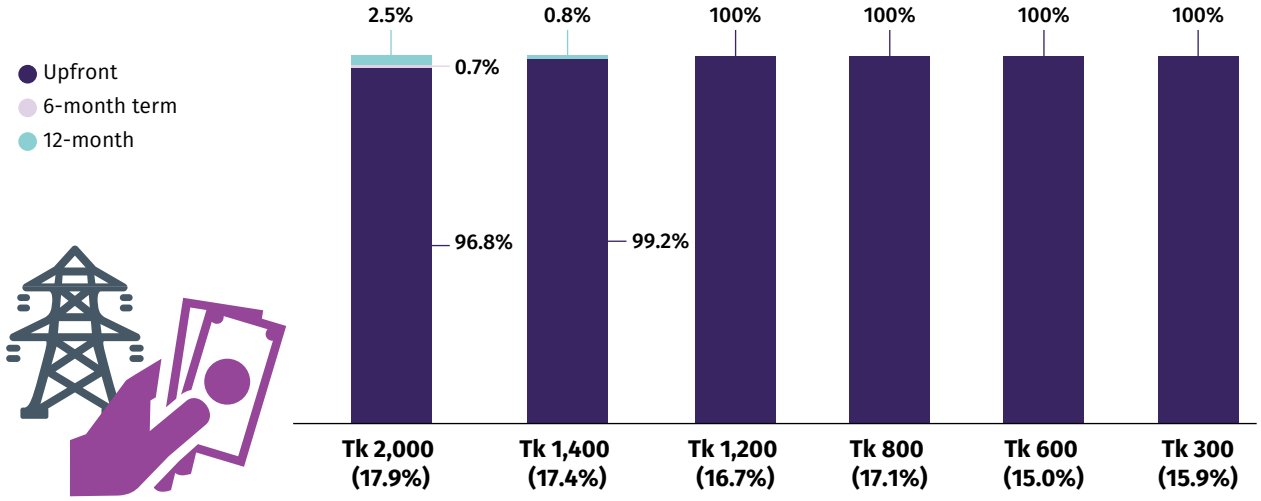
Source: MTF household survey 2017.

a connection fee (FIGURE 16 • Household's willingness to connect to gridigure 16). Only 1.6% of the households would connect only if the connection fee is waived, and 0.6% would not connect to the grid at all.[24]

[24] Households that do not want to connect to the grid mentioned high monthly expenditure as the reason for their unwillingness to connect.

Among the households that are willing to pay for grid connection, all want to pay upfront the connection fee except for the highest two offered prices—Tk 2,000 and Tk 1,400—for which they want to pay in installments (FIGURE 17 · Distribution of households by willingness to pay for grid connection by payment options (percent) figure 17). The shares of households that would like to pay for the connection fee on a 12-month installment plan at these two prices are 2.5% and 0.7%, respectively.

FIGURE 17 · **Distribution of households by willingness to pay for grid connection by payment options (percent)**



Source: MTF household survey 2017.

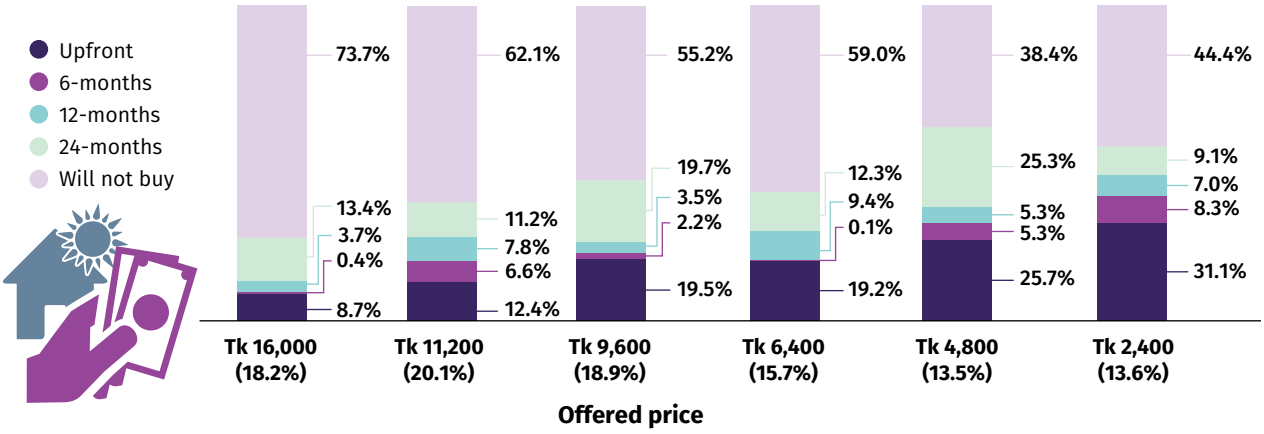
A substantial share of the households (33% of the non-grid households) are not connected to the grid because it is unavailable in the community or too far. For these households, off-grid solutions, in particular SHS, may be a viable option for accessing electricity. Bangladesh has one of the most successful SHS delivery programs in the developing world, which distributes SHSs through a microcredit-based financing scheme.[25] To assess Affordability for SHS, a WTP analysis has been carried out for eligible households.[26] Households were randomly offered an SHS unit of 50 watt-peak (Wp) at a price from a range of pre-selected values.[27] As expected, more and more households would pay the full price up front for an SHS as the offered price goes down—8.7% at Tk 16,000 (or US$195) and 31% at Tk.2,400 (or US$29) (Figure 18). In addition, the share of households that will not buy an SHS goes down as the offered price decreases. More specifically, at the highest offered price 13.4% households declined to purchase an SHS unit, while the share of such households drops to 6 % at the lowest offered price. Overall, the WTP is very low. Most of these households (78% of the non-grid households) mentioned lack of affordability as the reason for declining.

[25] This program is administered by IDCOL, which receives funding from foreign investments, including from the World Bank. The program had installed more than 5 million SHS units in rural Bangladesh by the time this survey was conducted, bringing electricity to over 20 million people or over 12% of the country's population. For more information on the SHS delivery program in Bangladesh, see Khandker at al. (2014).

[26] These households do not have access to the grid or an SHS.

[27] Watt-peak (Wp) is the maximum electric power provided by a solar panel in optimum condition. This is widely used to represent the capacity of an SHS unit.

FIGURE 18 • **Households' willingness to pay for a solar home system at different prices**



Source: MTF household survey 2017.
Note: Figures in parentheses are eligible households that were offered an SHS at a specific price.

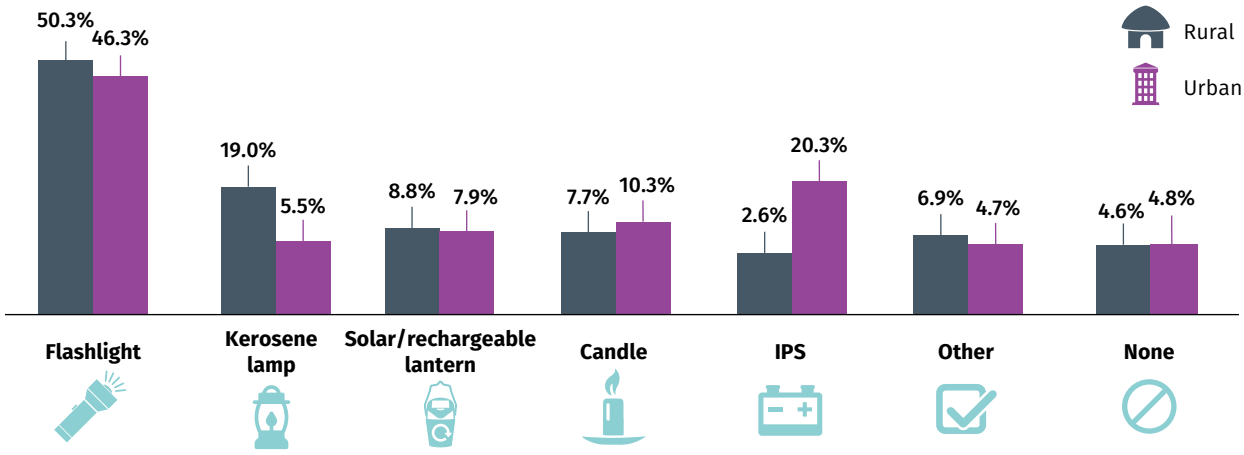
Improving access for grid-connected households

While availability and cost are major issues that keep households from accessing electricity, households with connection have access issues as well. Key issues that the grid-connected households in Bangladesh face are insufficient electricity supply (Evening Availability), frequent interruptions (Reliability), and voltage fluctuations (Quality)—in both rural and urban areas. It is apparent that Availability in the evening is the most common constraint across tiers and locations. More specifically, Availability in the evening is the main concern for the households in Tiers 1–3, affecting about 70.6% of the rural grid-connected households and 78.3 % of urban households. These households do not get 4 hours of service during the peak evening hours of 6–10 pm. This is not to imply that daily Availability is not a problem for these households. In fact, 95% of the grid-connected households constrained by evening duration have also issues with daily duration. Daily Availability, by itself, is a constraint for 6.2% of the urban households (Tier 4 households). It is likely that many households can be moved up to the next higher tier by increasing electricity Availability.

Reliability and Quality are also concerns—79.6% grid-connected households in rural areas and 44.7% in urban areas experience more than 14 interruptions per week (FIGURE 10 • Distribution of households based on Reliability (urban, rural, and nationwide)), and about 12% households experience low or fluctuating voltages (FIGURE 11 • Distribution of households based on Quality (urban, rural, and nationwide)). These issues must be resolved to shift these households to higher tiers.

To deal with insufficient supply and frequent interruptions, households use backup sources. Households using a flashlight as a backup source constitutes the highest share regardless of locations—it is 50% in rural areas and 46% in urban areas as shown in Figure 19. Among other sources, there is some variation between rural and urban areas. For example, 19% of the rural grid-connected households use kerosene as a backup source for lighting, whereas kerosene use is limited to only 5.5% of the urban

FIGURE 19 • **Backup sources of lighting for grid-connected households**

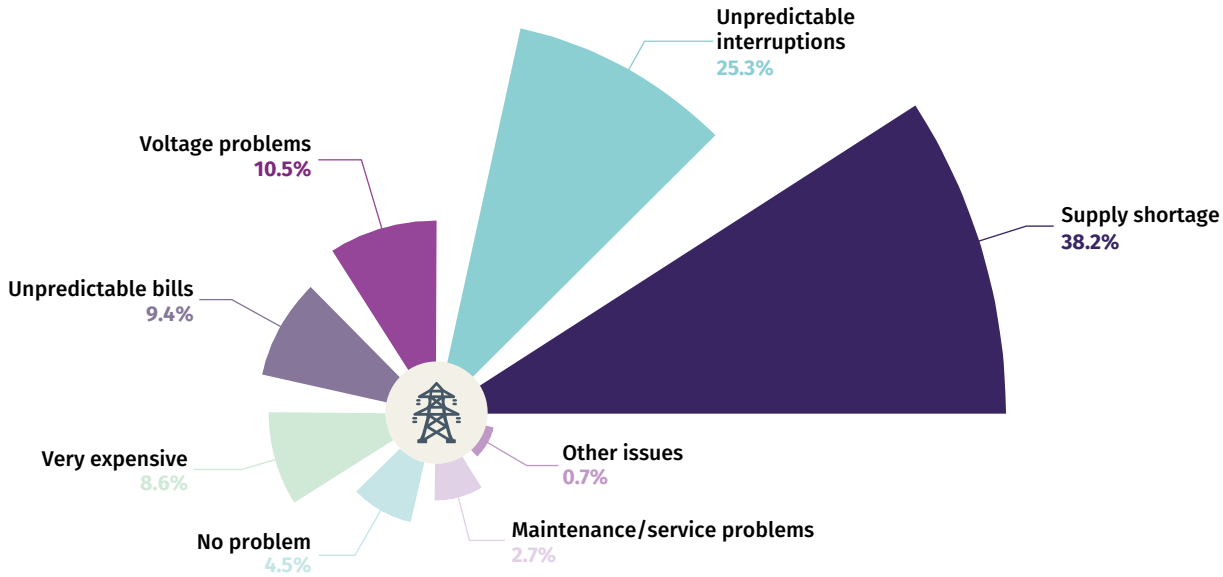


Source: MTF household survey 2017.

households. Urban households (20%) use, next to flashlights, mostly instant power supply (IPS).[28] Use of rechargeable lanterns or candles is low—about 10% or less.

Grid-connected households were asked about the problems they face with electricity service. The most serious problem reported is the supply shortage (not enough hours of electricity), reported by 38% of the grid households (FIGURE 20 • Distribution of households by self-reported problems of grid serviceigure 20). This is followed by unpredictable interruptions (25.3%) and voltage problems (10.5%). Only 4.5% of the grid households reported having no issues with the electricity service. Interestingly, these self-reported service issues are very much in line with the results from MTF attribute analysis.

FIGURE 20 • **Distribution of households by self-reported problems of grid service**



Source: MTF household survey 2017.

[28] IPS stores power from grid electricity in a battery when service is available and uses the power during hours of outages. IPS is fairly common in Bangladesh, especially in urban areas.

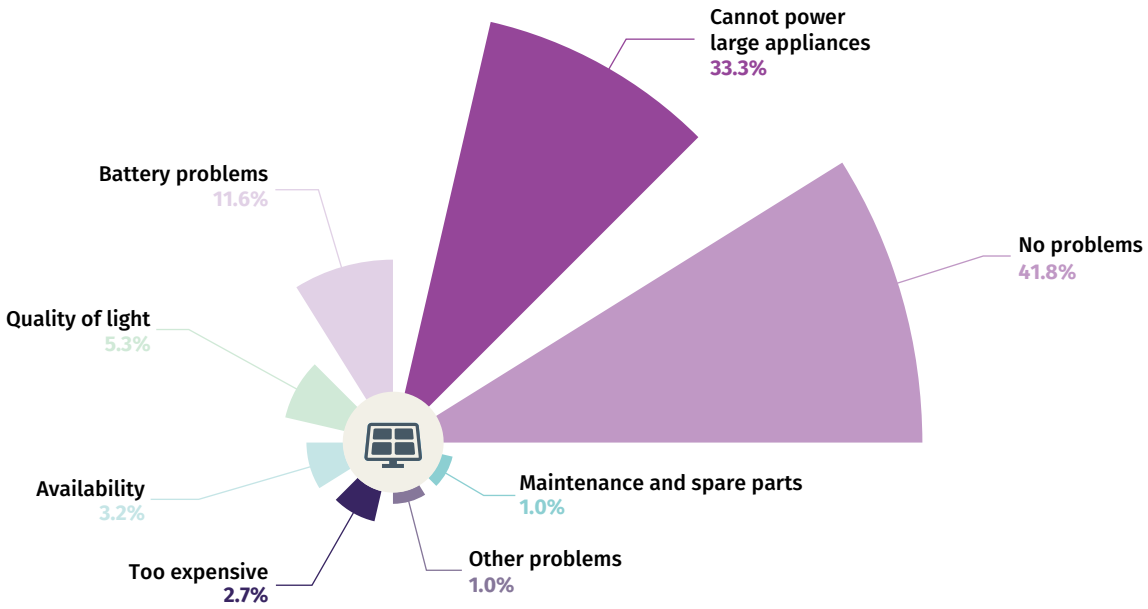
Improving access for off-grid households

Analysis has been limited to off-grid rural households only because the share of off-grid households is negligible in urban areas (0.4%). Off-grid households vary quite a bit from grid-connected households in terms of constraints.

SHS households face multiple issues, as apparent from MTF findings as well as self-reporting. Capacity seems to be an issue for an overwhelming share of off-grid rural households (96.3% of SHS households or 8.8% of all rural households), restricting these households to Tiers 0 and 1. Households also reported that they cannot power appliances that require large system capacity (33.3%). This may change if these households start using higher-capacity SHS units, which may soon be commercially viable in Bangladesh.

Maintenance of battery and SHS is another issue that households using solar solutions raised: 11.6% of them reported that batteries are an issue (Figure 21). Due to the battery problem, the small capacity of SHS units, or poorly maintained systems, these households may not be able to receive sufficient electric services. About 3.8% of households using off-grid solar solutions have less than 4 hours of electricity daily, which is not far off from the share of self-reporting households that say that Availability is an issue (3.2%). Only about 5% of these households get Tier 5 level of Availability. The Availability issue could also be due to poorly maintained systems or battery.

FIGURE 21 • **Main issues with off-grid solar products (rural areas)**



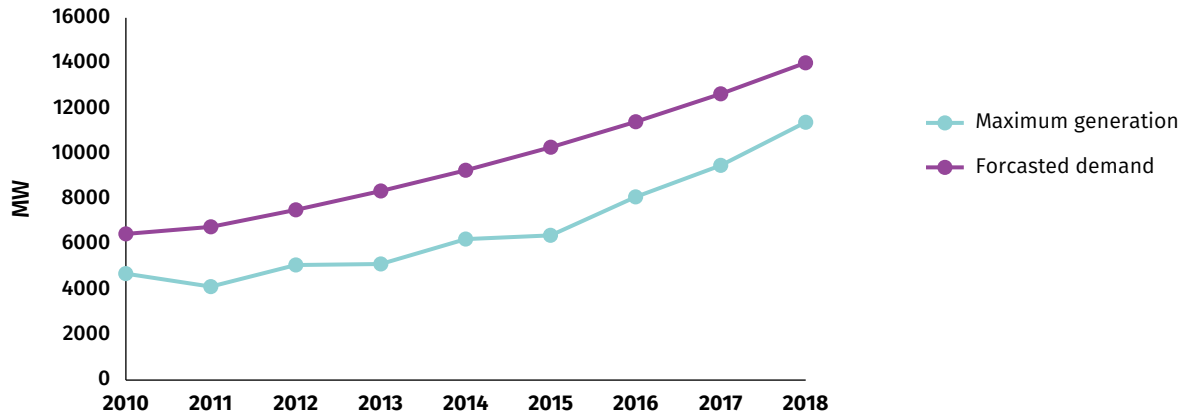
Source: MTF household survey 2017.

POLICY RECOMMENDATIONS ON ELECTRICITY ACCESS

Access to electricity in Bangladesh has doubled during the past eight years, and the country has been progressing well toward achieving 100% connectivity by 2021, which is the target defined in Vision 2021. Almost all households without access (12% of the population) live in rural areas, and about 40% of them applied for a grid connection at the time the MTF survey was being carried out. For a small share of households—the ultra-poor segment of the population—connection cost or the monthly consumption cost is an issue. Subsidized connections and tariff can be options for these households to get grid connectivity. Most other households without access are located in off-grid areas and can get access by adopting an SHS or connecting to mini-grid if available in the community.[29] Since the willingness to pay has been found low for a substantial share of these households (again, mostly ultra-poor), the microcredit-based financing scheme that works for most people may not be appropriate for them. Thus, alternate solutions (for example, rental scheme such as pay-as-you-go or subsidized dissemination of SHS units) may be needed.

- *Increase the generation capacity:* Among the households with grid access, evening Availability in particular is a major issue. Insufficient electricity supply points to insufficient generation. While Bangladesh has made substantial progress in increasing its generation capacity in recent years, it is still not enough to meet the increasing demand. As Figure 22 shows, the demand has always been higher than the maximum generation. Unless generation is increased at a higher rate, this gap will remain or widen. To tackle the problem of ever-growing demand, the government has outlined a number of steps in the Power System Master Plan 2016.[30] Government measures include multi-billion dollar investments to enhance the capacity of a few existing plants on an immediate basis; partnership with private and international parties to construct new power plants; investment in renewable energy technology, with a goal of meeting 10% of the country's electricity generation with renewable energy by 2020; diversification of fuel sources to stabilize the electricity generation in the future; and expansion of electricity import from neighboring countries. If the aforementioned programs are implemented properly, the service availability will doubtless improve.

FIGURE 22 • **Maximum electricity generation versus forecast demand**



Source: Power System Master Plan 2016, Power Division, Bangladesh Ministry of Power, Energy and Mineral Resources.

[29] IDCOL has a solar mini-grid program to provide electricity for households in remote, isolated, and riverine locations in the country. By 2018, 18 such projects were approved and 7 were operational, serving about 5,000 households.

[30] Government has forecast a demand of 33,700 MW in 2030 and planned to increase its generation capacity to 40,000 MW by then to meet or surpass the demand.

- *Improve the quality of transmission and distribution infrastructure:* While lack of availability is due to generation problems, frequent interruptions, and voltage fluctuations—which are also issues with the grid service in Bangladesh—point to problems in transmission and distribution lines. The transmission and distribution infrastructure in Bangladesh is old and dilapidated, which causes substantial system losses, in addition to frequent and prolonged outages. While Bangladesh has expanded its transmission and distribution network by about 20% and 40%, respectively, it has not kept pace with the increase in generation capacity. The government has plans for constructing new transmission lines all over Bangladesh, including connecting Dhaka (national capital) to all regions with 400 kV transmission lines. International donors such as the World Bank and the Asian Development Bank have also funded transmission projects recently. Furthermore, the government is installing prepaid meters in the substations to lower system losses, which have already gone down during the past several years and stand now at 9.3%. The government has plans to replace all analog meters with prepaid meters within next five years. Besides constructing new lines and substations, the government also has to repair and renovate old infrastructures, especially those older than 15 years. These and many other improvements can be incorporated into what is called "smart grid technology." Smart grid can substantially improve the distribution system with features such as advanced billing and metering, demand-side management, congestion management, advanced sensing, energy storage, and so on.
- *Improve Capacity and Availability attributes for off-grid solar solutions:* For SHS users, Capacity and battery issues are the main issues. Since the limitation of Capacity is built in the system, not much can be done about it. However, with a rapid price-drop, high-capacity SHS units would soon be available in the Bangladesh market at affordable prices. Moreover, with the advance in energy efficiency technology, households could receive more electricity services than is currently possible, at the same or lower capacity. The second issue that plagues the SHS users has to do with the battery. This issue may arise from a number of factors: undercharging and overcharging of batteries, continued use of expired batteries, and so on. The life of battery life and its functionality depends on proper care and maintenance. Improved user training may be needed to reap maximum benefits from batteries.

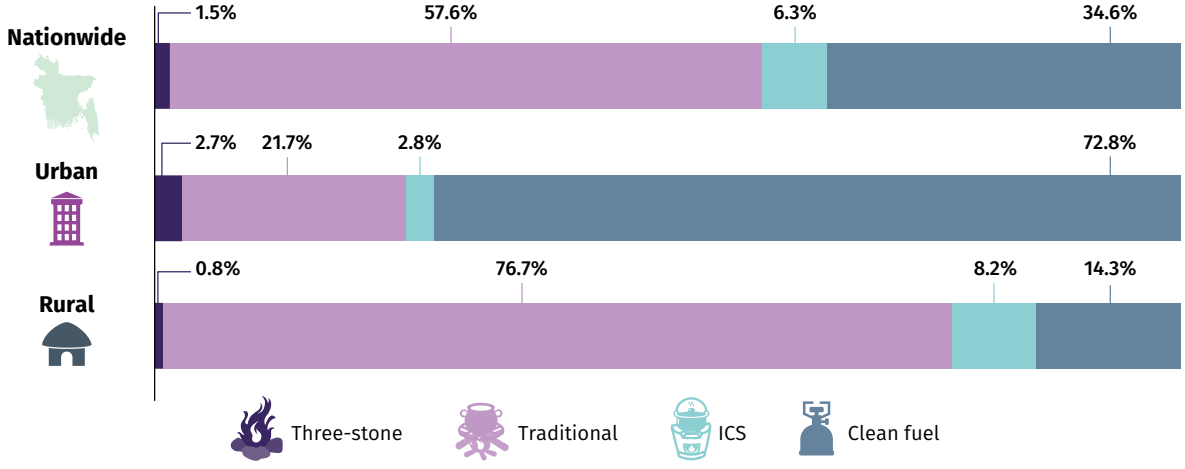
ACCESS TO MODERN ENERGY COOKING SOLUTIONS

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

TECHNOLOGY

Nationwide, the majority of the households use traditional stoves as their main cookstove (57.6%), followed by clean cookstoves (34.6%) and improved cookstoves (ICSs) (6.3%) (figure 23).[31] Clean cookstoves are mostly gas stoves—liquefied petroleum gas (LPG), piped natural gas (PNG), and biogas—and a very small share (about 1%) of electric induction stoves (in urban areas only). There is a large variation between urban and rural areas—a large majority of cookstoves in urban areas are clean cookstoves (72.8%), while in the rural areas traditional stoves are most prevalent (76.7%). ICSs are, as expected, more common in the rural areas—8.2% of the main stoves in the rural areas are ICS, while in the urban areas only 2.7% households use them as their main stoves.[32]

FIGURE 23 • **Distribution of households by main cookstove (urban, rural, and nationwide)**



Source: MTF household survey 2017.

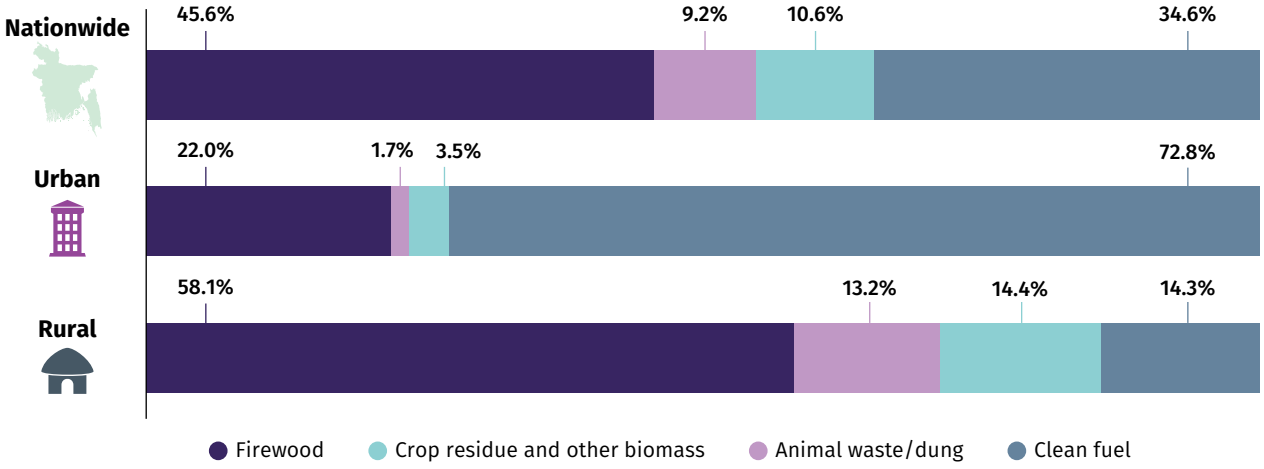
[31] The "main" cookstove is the one used most of the time in the household. Households were asked to identify their main cookstove if they use multiple stoves. From the MTF perspective, a household must have one and only one main cookstove.

[32] Defining ICS can be tricky since some of these improved cookstoves are manufactured by different producers and their standards vary. In Bangladesh, ICSs are promoted by entities such as government agencies (for example, IDCOL), local NGOs (for example, Grameen Shakti), and donors (such as GIZ). These stoves have certain features such as isolated combustion chambers, higher thermal efficiency than traditional mud stoves, sometimes built-in chimneys, and grates for holding ashes. These stoves are often known by names such as *Shakti chula*, *Shikha chula*, and *Agni chula*.

FUEL USE

While fuel usage is determined to a large extent by stove ownership, households with biomass stoves use various types of biomass fuels (FIGURE 24 • Cooking fuel used by the household: Main fuel in main stove (urban, rural, and nationwide)). Biomass, more specifically firewood, constitutes the largest share of fuels used in rural areas and nationwide: 45.6% of the households nationwide, 58.1% in rural areas, and 22% in urban areas use firewood as their main fuel. A substantial share of households in rural areas (27.6%) also use other biomass fuels such as animal waste and crop residue. Clean fuel (piped natural gas or PNG, liquefied petroleum gas or LPG, biogas and electricity) constitutes by far the largest share of cooking fuels used by the urban households—it is used by 72.8% of the urban households but only 14.3% of the rural households.

FIGURE 24 • **Cooking fuel used by the household: Main fuel in main stove (urban, rural, and nationwide)**



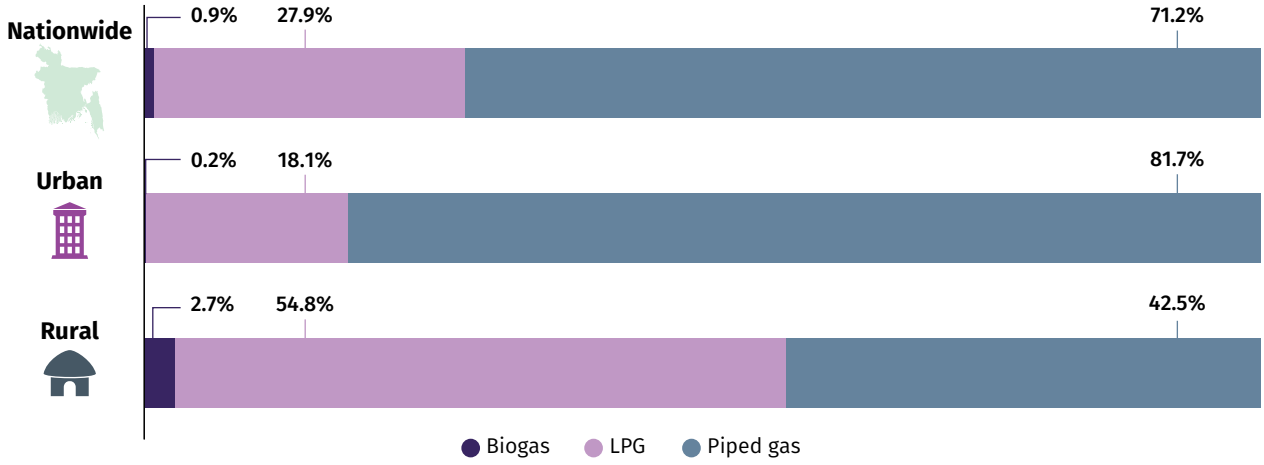
Source: MTF household survey 2017.

Among the clean fuels, electricity's share is less than 1% only and gas is the predominant clean fuel used in Bangladesh (Figure 25). In urban areas, PNG is the fuel of choice for 81.7% of households using clean fuels. In rural areas, on the other hand, LPG is more common, as the piped network is not well established. As the reserve of natural gas in Bangladesh is shrinking fast, government is promoting LPG use for cooking, and LPG is projected to be the future of clean fuel.[33] Biogas is used only on a limited scale—more in rural areas than in urban areas.

[33] The current reserve of the country's natural gas is estimated at 10–12 trillion cubic feet; about 1 trillion cubic feet is consumed every year. So, unless new gas fields are discovered, the current reserve will be exhausted within a decade.

STOVE STACKING AND FUEL STACKING

FIGURE 25 • **Distribution of gaseous cooking fuels in Bangladesh (urban, rural, and nationwide)**



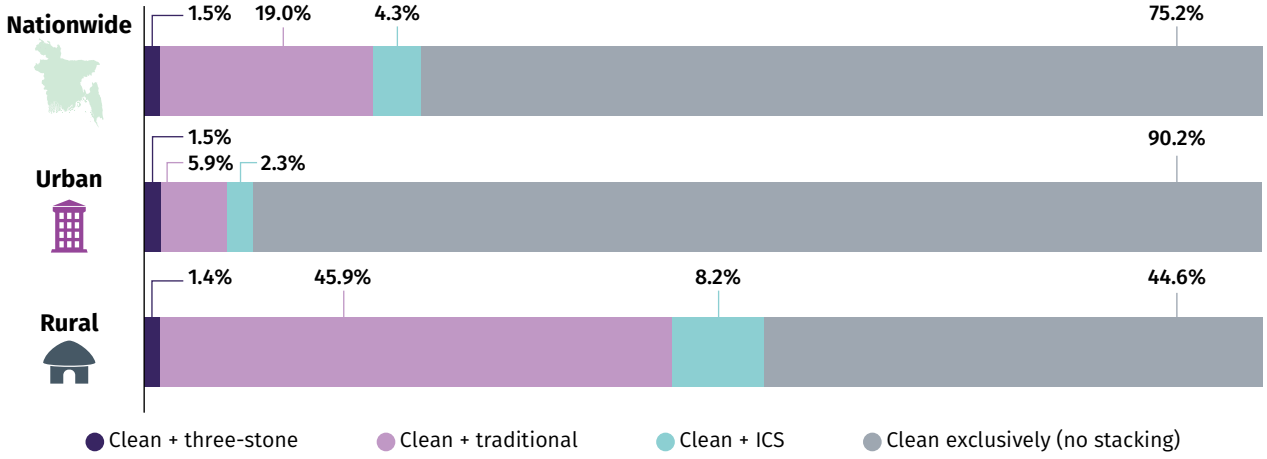
Source: MTF household survey 2017.

Stove stacking (use of multiple stove types) is often practiced, as one stove often does not satisfy the cooking needs of the household. Stove stacking may also happen when households use certain stoves for specific purposes only. For example, some households may use LPG stoves only for light cooking such as boiling water to make tea or preparing snacks while using traditional stoves to cook main meals. The choice of stove stacking may depend on cultural practice or habits that cannot be easily changed regardless of the availability of alternate options. Stove stacking within clean cookstoves (use of LPG stoves and electric stoves by the same household, for example) is not an issue. However, stacking clean cookstoves with biomass stoves may be a cause for concern, as this practice negates the benefits of clean cooking—health benefits and efficiency, for example.[34] So, in this study, the focus is on the stacking of clean cookstoves with biomass stoves only.

In Bangladesh, the scope of stove stacking is limited, as this study finds that most households (89%) use one stove type exclusively.[35] Figure 26 shows the extent of stacking of biomass stoves among the users of clean cookstoves. Stove stacking is an issue in the rural areas—55% of clean stove users in rural areas also use biomass stoves, mostly traditional stoves. On the other hand, only 10% of the clean cookstove users in urban areas are found to use biomass stoves. Overall, the extent of stove stacking is less than 25% among the clean cookstove users.

[34] It can be argued that stacking of biomass stoves and clean cookstoves is better than using biomass stoves only. While that may be true, it is not something to recommend while promoting clean-cooking solutions.
[35] This figure seems to underestimate the extent of use of multiple stoves.

FIGURE 26 • **Extent of stacking of biomass stoves among clean cookstove users (nationwide, urban, and rural)**



Source: MTF household survey 2017.

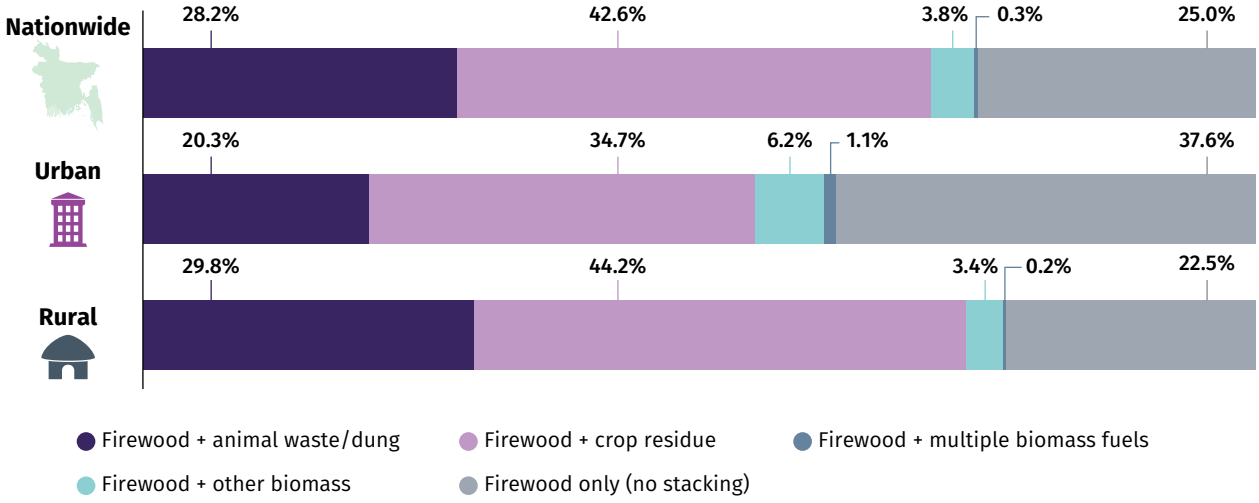
What is even more worrisome is that households that are involved in stove stacking use their biomass stoves more than their clean stoves (Figure 27). Nationwide, households engaged in stove stacking use their biomass stoves 60% of the time—104.6 minutes/day as opposed to 66.6 minutes/day for clean cookstoves. This implies that most households who are engaged in stove stacking do not prepare their main meals using clean cookstoves.

FIGURE 27 • **Duration of stove use within households who stack biomass and clean cookstoves: Minutes per day: (urban, rural, and nationwide)**

Source: MTF household survey 2017.

Fuel stacking is the use of multiple fuels to meet cooking needs. Fuel stacking is often viewed as the household response to fuel scarcity and price fluctuation (Akpalu Dasmani, and Aglobitse 2011). In addition, individual preferences play a role in the choice of fuels. For example, it is sometimes the perception that certain foods taste better when cooked with firewood (Akpalu, Dasmani, and Aglobitse 2011; Ouedraogo 2006). Stacking clean and biomass fuels basically mirrors stove stacking, which has already been discussed. What is more meaningful is to examine fuel stacking across and within biomass stoves. Since biomass fuels can vary in energy content, stacking of biomass fuels between firewood and non-firewood biomass fuels can be an issue. As Figure 28 shows, 75% of the households that use firewood also use other biomass fuels; the corresponding figures for urban and rural households are 62.4% and 77.5%, respectively. Crop residue is the most common biomass fuel stacked with firewood, followed by animal waste and other biomass fuels.[36] The incidence of stacking with multiple biomass fuels is very low.

FIGURE 28 • **Stacking of non-firewood biomass fuels among firewood users (urban, rural, and nationwide)**



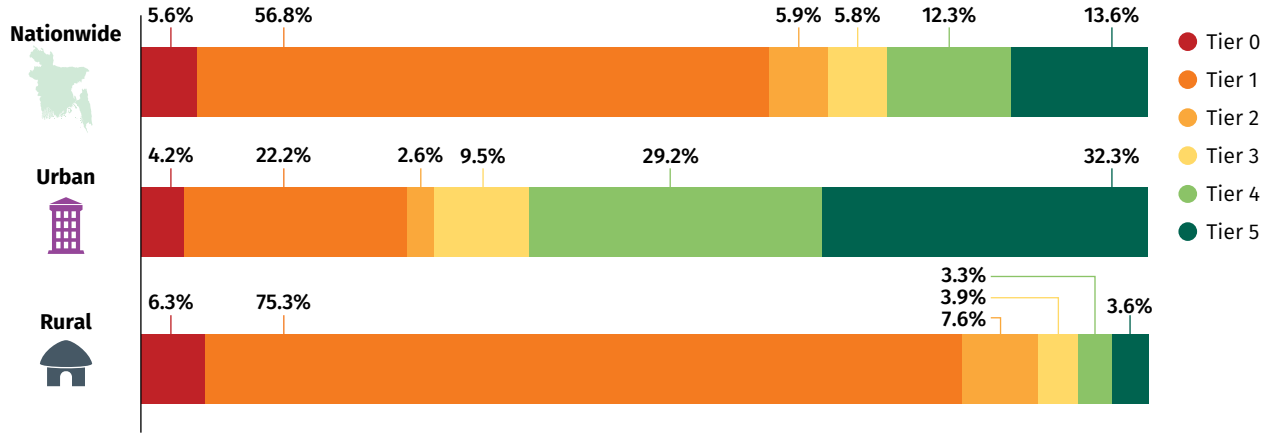
Source: MTF household survey 2017.

MTF ANALYSIS

There is a wide rural-urban gap in MTF tier distribution for access to modern energy cooking solutions (Figure 29). Tier 1 is the dominant tier in rural areas, covering 75.3% of the households, while in the urban areas there is no dominant single tier. Tier 5 comprises the highest share of urban households (32.3 %), followed closely by Tier 4 (29.2%) and Tier 1 (22.2%). Overall, 56.8% of households in Bangladesh are in Tier 1. The share of rural households in higher tiers (4 and 5) is very low—less than 7%. While a large majority of the urban households are in higher tiers (over 61%), over a quarter of them are in lower tiers (Tiers 0 and 1).

[36] Crop residues are mostly straw and rice husk. Other biomass fuels used by the households are leaves, jute sticks, bagasse, and so forth.

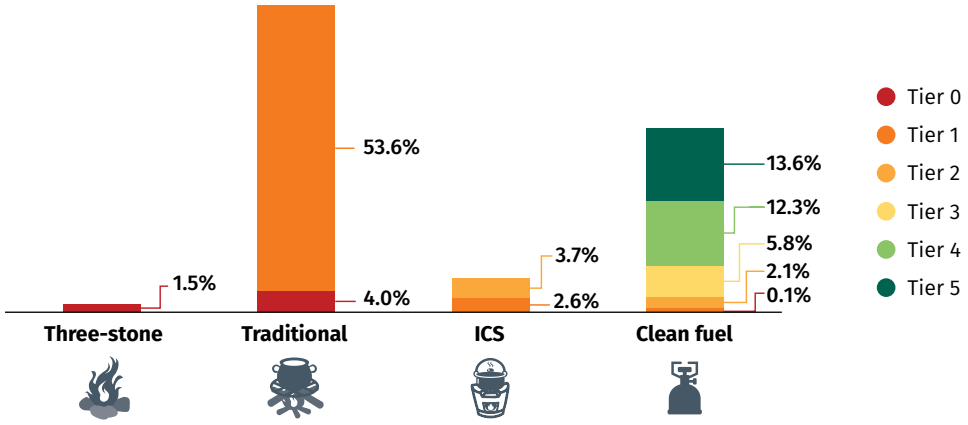
FIGURE 29 • **MTF aggregate tier for cooking solutions (urban, rural, and nationwide)**



Source: MTF household survey 2017.

To explore the relationship between cookstoves and tiers further, tier distribution by the main cookstove is analyzed (Figure 30). Three-stone stove users are all in Tier 0 and traditional stove users are mostly in Tier 1. While 3.7% of the households use ICSs and are in Tier 2, 2.6% of the households using ICSs are still in Tier 1. As for the clean cookstove users, almost 26% are in higher tiers (4 and 5), but 5.8% are in Tier 3 and the rest are in lower tiers. This means that, while the adoption of clean cookstoves is a necessary condition for reaching higher tiers, it is not a sufficient one, as there are other factors that may determine cooking tiers. Such underlying factors are examined in the Attribute analysis.

FIGURE 30 • **MTF aggregate tier by main cookstove type**



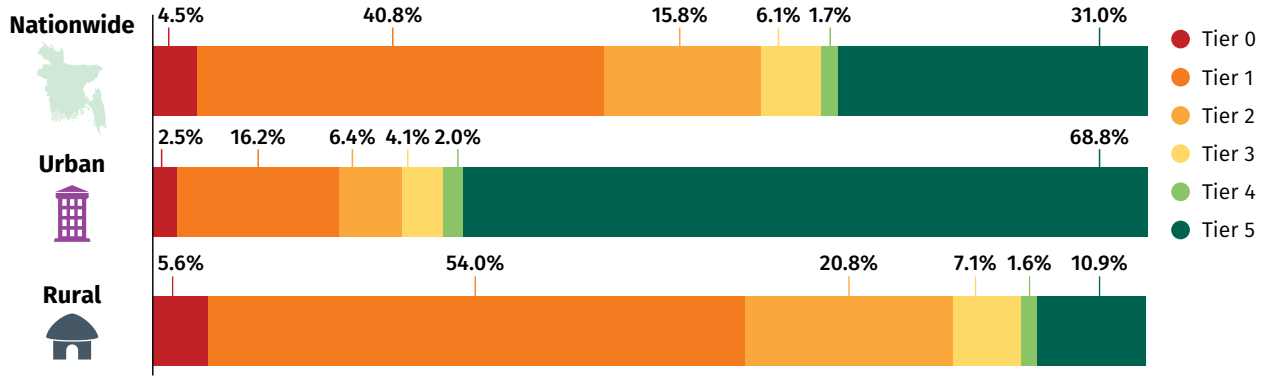
Source: MTF household survey 2017.

MTF ATTRIBUTES FOR COOKING SOLUTION

Cooking Exposure

The Cooking Exposure attribute represents an estimate of personal exposure during cooking activities based on the emissions from cooking and the ventilation. The majority of rural households are in Tier 1 (54%), while the majority of the urban households are in Tier 5 (68.8%) (Figure 31). Overall, more than 40% of the households in Bangladesh are in Tier 1—these households use mostly traditional stoves. As women are overwhelmingly the main cook in Bangladesh, they bear the brunt of harmful emissions from cooking, and our findings suggest that a large majority of rural women in Bangladesh are subject to it.

FIGURE 31 • **Tier distribution for the Cooking Exposure attribute (urban, rural, and nationwide)**

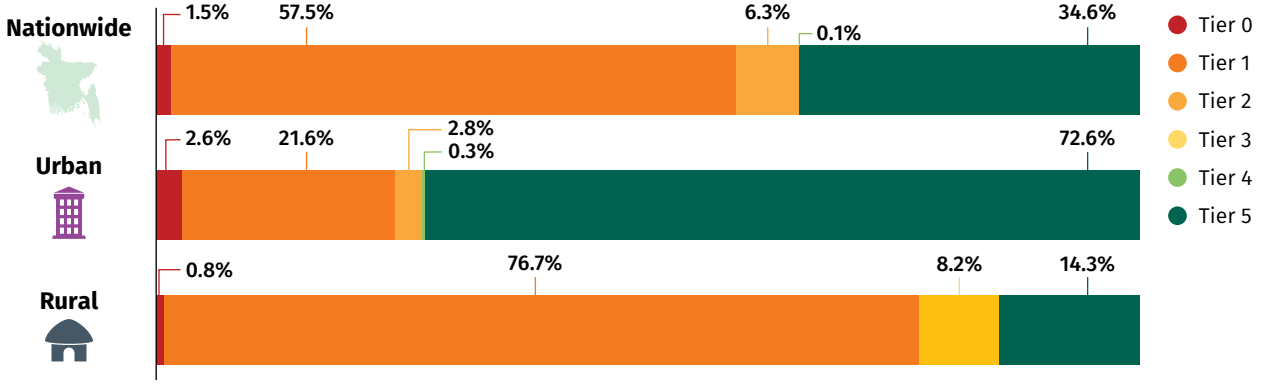


Source: MTF household survey 2017.

Cookstove Efficiency

Cookstove Efficiency refers to the thermal efficiency of the main cookstove. A large majority of the rural households, who mostly use traditional mud stoves, are in Tier 1 for Cookstove Efficiency (76.7%) (Figure 32). Also, 8.2% of the rural households are in Tier 2 and are users of ICSs. The majority of the urban households, who use clean cookstoves, enjoy Tier 5 status in Cookstove Efficiency.

FIGURE 32 • **Tier distribution for Cookstove Efficiency attribute (urban, rural, and nationwide)**

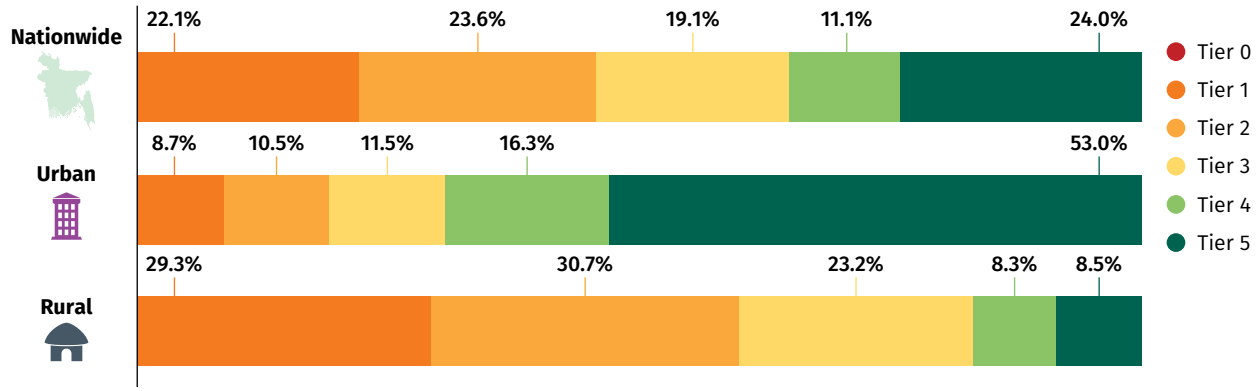


Source: MTF household survey 2017.

Convenience

The attribute of Convenience is based on the time spent acquiring fuels (through collection or purchase) and preparing fuels and the stoves for cooking. Nationwide, about one-fourth of the households are in the highest tier for Convenience, but a substantial share of the households is in the lowest tier (22.1%) (Figure 33). As observed for other attributes, there is an urban-rural gap. More than 50% of the urban households are in Tier 5, while less than 9% of the rural households are in the highest tier. What is disturbing is that about 15% of the households that use clean cookstoves are still in Tiers 1–3. A majority of these households are from rural areas, where LPG distribution, refilling logistics, or the supply-chain network is probably inadequate. People in some rural areas have to wait long to collect new cylinders or refill old ones.

FIGURE 33 • **Tier distribution for the attribute of Convenience (percent)**

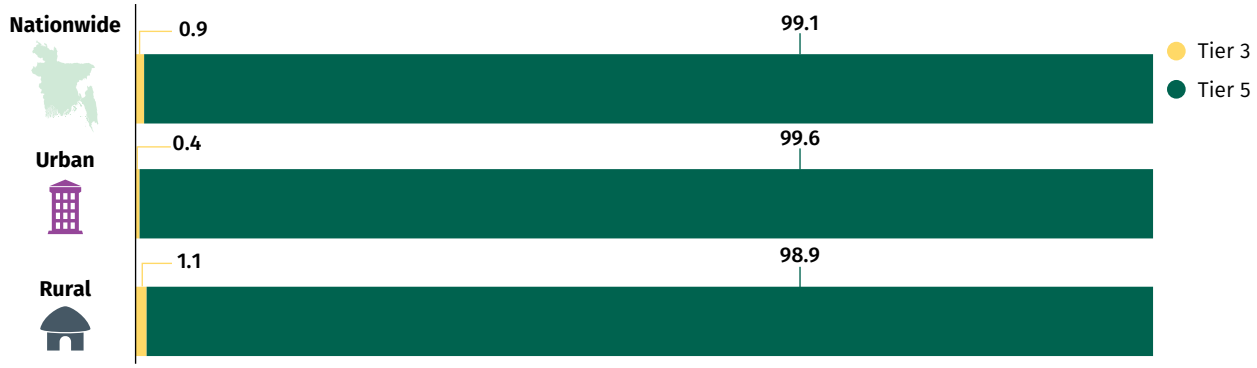


Source: MTF household survey 2017.

Safety of Primary Cookstove

The attribute of Safety of Primary Cookstove is a binary attribute, determined by the incidents of serious health issues arising from the use of the main cookstove during the year preceding the survey. Households are assigned Tier 3 if they report any such incidents, and Tier 5 otherwise. It is obvious from Figure 34 that safety of the cookstove is a nonissue in Bangladesh as about 99% households reported no incidents. Rural and urban households do not vary in that regard.

FIGURE 34 • **Tier distribution for the attribute of Safety (urban, rural, and nationwide)**

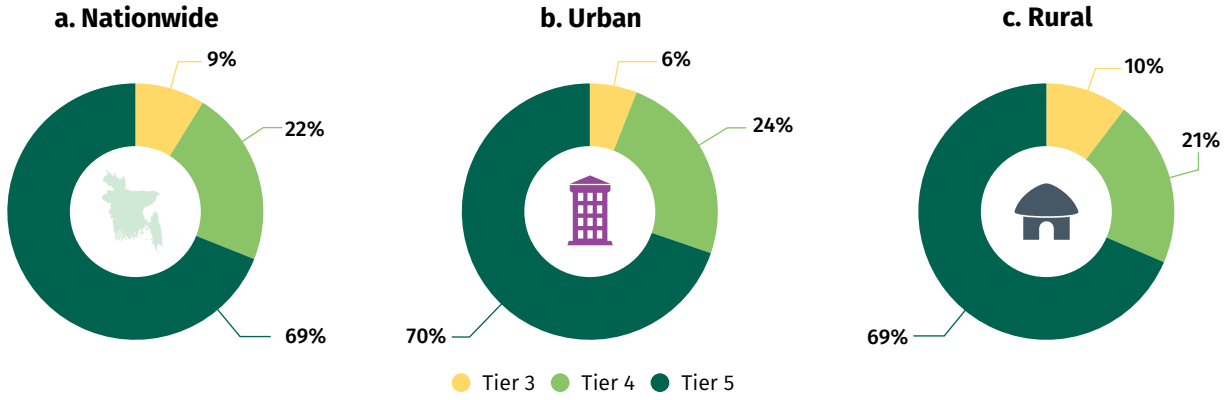


Source: MTF household survey 2017.

Fuel Availability

For a majority of the households in Bangladesh, the primary cooking fuel is always available (69%), and there is no difference between urban and rural households (Figure 35). However, a sizable share (over 30%) of the households also report issues with Fuel Availability. Issues in rural areas are not surprising, where firewood is the primary fuel for a majority of the households, and it has become scarce and expensive because of continuous deforestation. However, in urban areas, the nature of fuel scarcity is different. The majority of the urban households use PNG, which has been the fuel of choice for about 40 years. However, the natural gas reserve of the country has been declining, and as a result, the supply for residential cooking has become patchy over past 15 years or so. Applications for new gas lines are now rarely approved, and urban households have started switching to LPG for cooking needs.

FIGURE 35 • **Tier distribution for Fuel Availability attribute (urban, rural, and nationwide)**



Source: MTF household survey 2017.

Affordability

Affordability is also a binary (yes-no) attribute and measured by levelized cost of cooking solution (stove and fuel). A household is assigned Tier 5 if the cost is less than 5% of its overall expenditure, and Tier 3 otherwise. In Bangladesh, the cooking solution is affordable for all households (as such, all households merit a Tier 5 status), and so, it is not reported using charts.

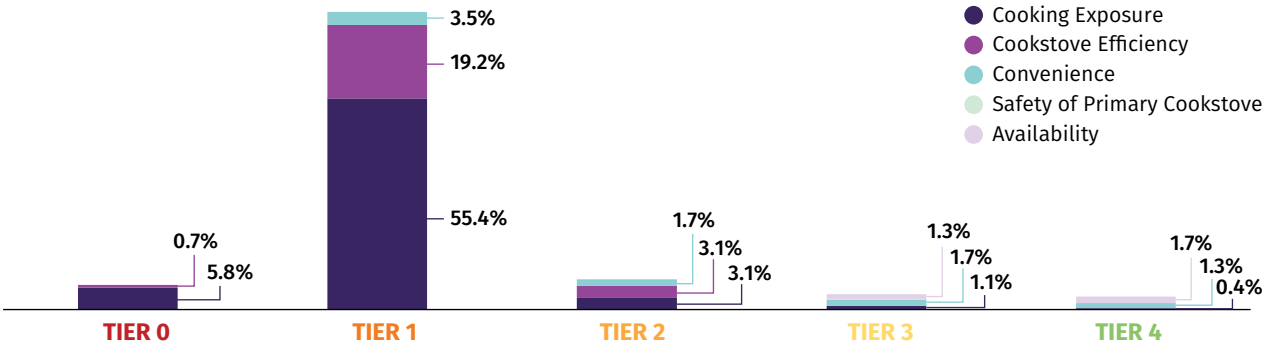
IMPROVING ACCESS TO MODERN ENERGY COOKING SOLUTIONS

Improving cooking solutions in rural areas

For lower-tier households (Tiers 0–2), Cooking Exposure is the dominant constraint, followed by Cookstove Efficiency and Convenience (Figure 36). On the other hand, for higher tier households (Tiers 3–4), whose share is low, Convenience is the major issue, followed by Availability and Exposure. Lower-tier households mostly use biomass stoves, which impacts emission levels, and consequently results

in higher exposure to indoor air pollution. Biomass stoves are also less efficient than clean stoves. For these households, the lack of Convenience in accessing as well as the Availability of the primary fuel may stem from the issues with collection.

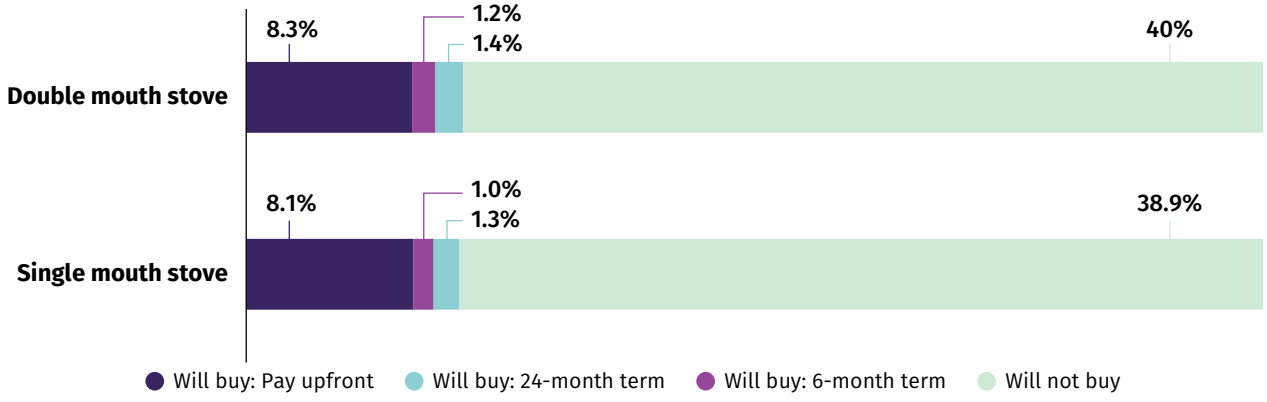
FIGURE 36 • **Distribution of constraints in cooking solutions in rural areas**



Source: MTF household survey 2017.

Cooking Exposure results are impacted by the widespread use of biomass stoves in Bangladesh, and this attribute can be used to assess whether the higher use of ICSs will reduce exposure. To that end, a willingness-to-pay (WTP) analysis for ICSs has been carried out. For households who use three-stone or traditional stoves only, one of the two ICSs was offered randomly—single mouth (Tk 450) and double mouth with chimney (Tk 900)—with varying payment terms.[37] About 40% of the rural households would not buy an ICS, and the type of the ICS or payment terms does not matter much in their decision (Figure 37). Only 8% of the rural households opt for up-front payment to purchase an ICS. Findings from the WTP analysis suggest that price is indeed an issue in the promotion of ICSs.

FIGURE 37 • **Willingness to pay for an improved cookstove**



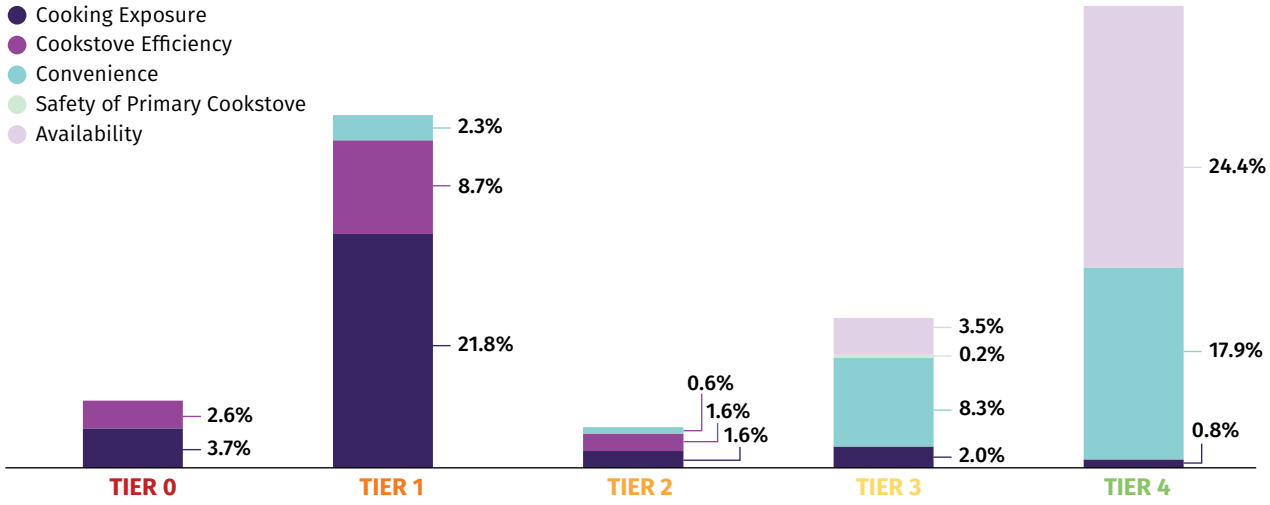
Source: MTF household survey 2017.

[37] Single mouth and double mouth imply single-burner and double-burner, respectively.

Improving cooking solutions in urban areas

Again, Cooking Exposure seems to be a major problem for lower tier (0–2) households, followed by Cookstove Efficiency (Figure 38). For higher-tier (3–4) households the major constraints are the same as they are for rural households—Convenience and Availability. The cooking practice of the lower tier households do not vary between rural and urban areas—both use solid fuels in most cases—and so they face the same problems. Higher tier households in the urban areas are, however, more dependent on PNG for cooking solutions, unlike rural households who use mostly LPG. However, as discussed before, urban households face the same Availability issues as their rural counterparts, because Reliability of the natural gas supply has increasingly become a problem.

FIGURE 38 • **Distribution of constraints in cooking solutions in urban areas**



Source: MTF household survey 2017.

POLICY RECOMMENDATIONS ON COOKING SOLUTIONS

The gap analysis carried out earlier provides insights on how access to cooking solutions can be improved by improving cooking attributes. Since some of these issues are interrelated, taking care of one often resolves another. For example, both Cooking Exposure and Efficiency can be improved substantially by switching from biomass-based (solid fuel) cooking to clean cooking solutions. Other suggestions follow:

- *Switching from three-stone or traditional stoves to ICSs*: Ideally, most cooking issues can be resolved by switching to clean cookstoves. However, given that complete transition to clean-cooking solutions would take some time and a vast majority of the rural households will continue to use biomass as a cooking fuel, the introduction of ICS, in the interim period, can improve the cooking experience over three-stone and traditional cookstoves by lowering exposure and increasing thermal efficiency. While Bangladesh's history with ICSs is not new, their use has not been sustainable so far and their penetration is modest at best (less than 10%). There are a few reasons for that. For example, an ICS

is more expensive than traditional stoves.[38] While the first stove is often subsidized or distributed for free, subsequent ones are not, and households, often unconvinced about the extent of benefits of ICSs, do not want to make a full investment on the second stove, and consequently go back to using traditional stoves. Thus, more awareness campaigns and sensitization about the health benefits of ICSs are needed to raise the reservation price of the potential users.[39]

- Lack of proper monitoring and after-sales service also contributes to diminished use of ICSs. Households often go back to traditional stoves when some features of an ICS (for example, the chimney) stop working.[40] Reassuringly, IDCOL has come up with an ambitious program that has so far installed 1 million ICSs in the rural areas and aims to install 4 million more (with up to Tier 3 level efficiency) by 2021. This program has a built-in incentive scheme for the partner organizations and well-designed marketing, monitoring, and after-sales components to promote ICS on a sustainable basis. For the ultra-poor households who cannot really afford ICS, a customized subsidy scheme may be needed.[41]

- *Promoting clean cooking solutions*: While ICSs are certainly better than traditional stoves, switching to clean cooking solutions should be promoted where it is feasible. The Government of Bangladesh has been making efforts to spread clean-cooking solutions using LPG. LPG is marketed usually in 12-kilogram cylinders and sold at a price of Tk 2,200–2,400 (US$26–29) per cylinder if imported. There are 13 companies in the market and 7 more have been given permission to sell LPG. Increasingly, people are moving toward LPG, including the urban population that currently uses PNG for cooking. One issue of concern is that LPG price is not regulated and thus does not often reflect the international price, something the government should take a look at. Also, more outlets and refill stations should be built, especially in the rural areas, to reduce price fluctuation and bring stability to the supply chain. This will also reduce the time of acquiring fuels and improve convenience.

- *Discouraging the use of biomass stove along with a clean fuel stove:* Stove and fuel stacking interfere with the benefits that the households are expected to reap from the adoption of clean cookstoves. However, in many cases a household's decision to stack stoves is rooted in cultural practice, and dissuading households from practicing stove or fuel stacking is not easy. What is needed is more campaigning to enhance the awareness on the benefits of clean cooking without stacking.

- *Improving ventilation*: Besides issues related to stove design and fuels, the cooking solution should also consider the issue of kitchen design, which is often ignored. Kitchen design is an essential component of the attribute of Cooking Exposure, and thus is very much relevant to MTF. While increasing kitchen volume may not be feasible, improving ventilation structure should be encouraged as it lowers Cooking Exposure.

- *Understanding broad-based development contexts:* Finally, it is important to remember that development interventions are most effective when they work in tandem, complement one another, and provide synergy. Thus, solutions to a problem should be looked at not in isolation but from a broader

[38] The MTF survey finds that traditional stoves in Bangladesh are almost always manufactured by the households themselves and rarely purchased. Even if the opportunity cost of the labor used to produce traditional stoves is considered, they are much cheaper than ICSs.

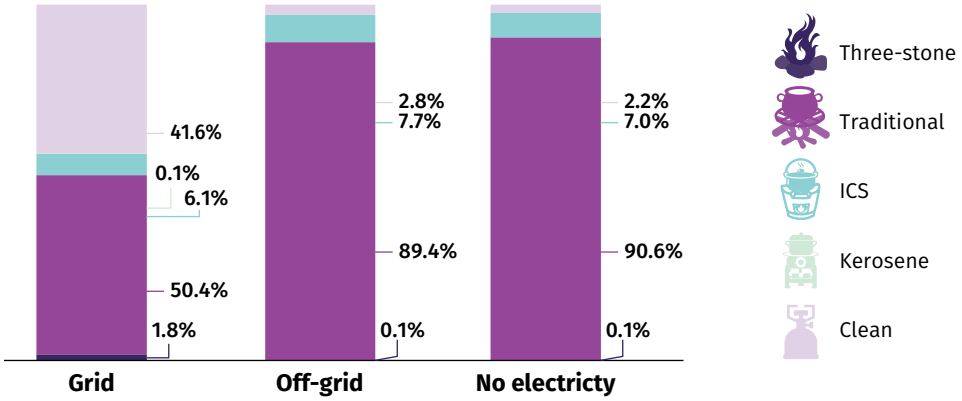
[39] The lack of sustainability of ICS adoption is a common finding in the literature, covering many developing countries (Khandelwal et al. 2017; Jürisoo, Lambe, and Osborne 2018; Miller and Mobarak 2013; Ray, Cliford, and Jewitt 2014; Rosenbaum, Derby, and Dutta 2015).

[40] The MTF survey did not collect information on after-sales service for ICS customers. However, it was identified as an issue by IDCOL, and they have incorporated an after-sales service component into their ICS program.

[41] The government has a subsidy program for promoting renewable energy solutions (which includes ICS), called KABITA, which uses funds from government's safety net program. This program is implemented by IDCOL.

perspective. In the context of MTF, it is worth examining whether the two modes of energy access—access to electricity and access to cooking solutions—are correlated and use the findings to improve our understanding of the interventions and make them more effective. Figure 39 shows how cookstove adoption varies by household's main source of electricity; and Figure 40 shows the relationship between MTF tier distribution for electricity access and that for access to cooking solutions.

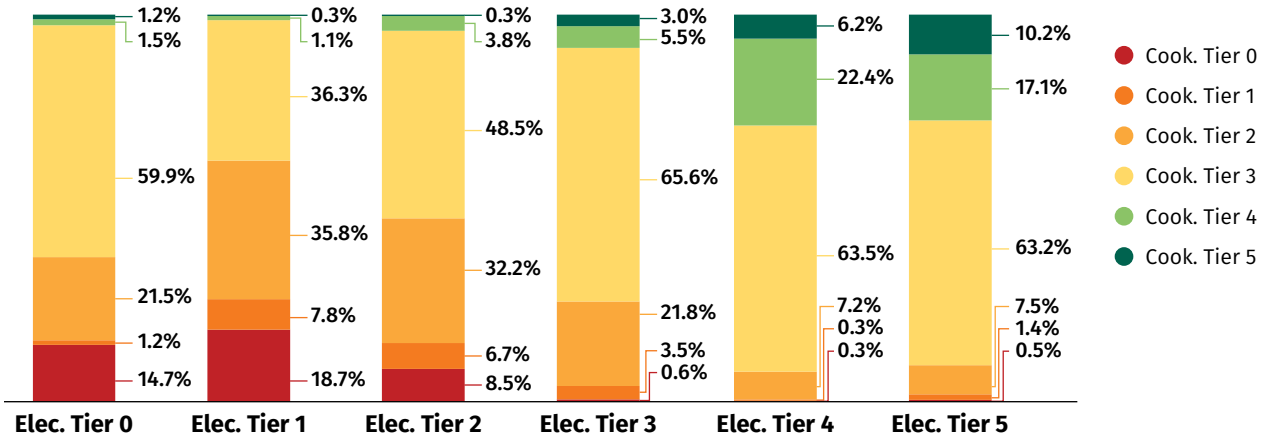
FIGURE 39 • **Household cookstove adoption by source of electricity**



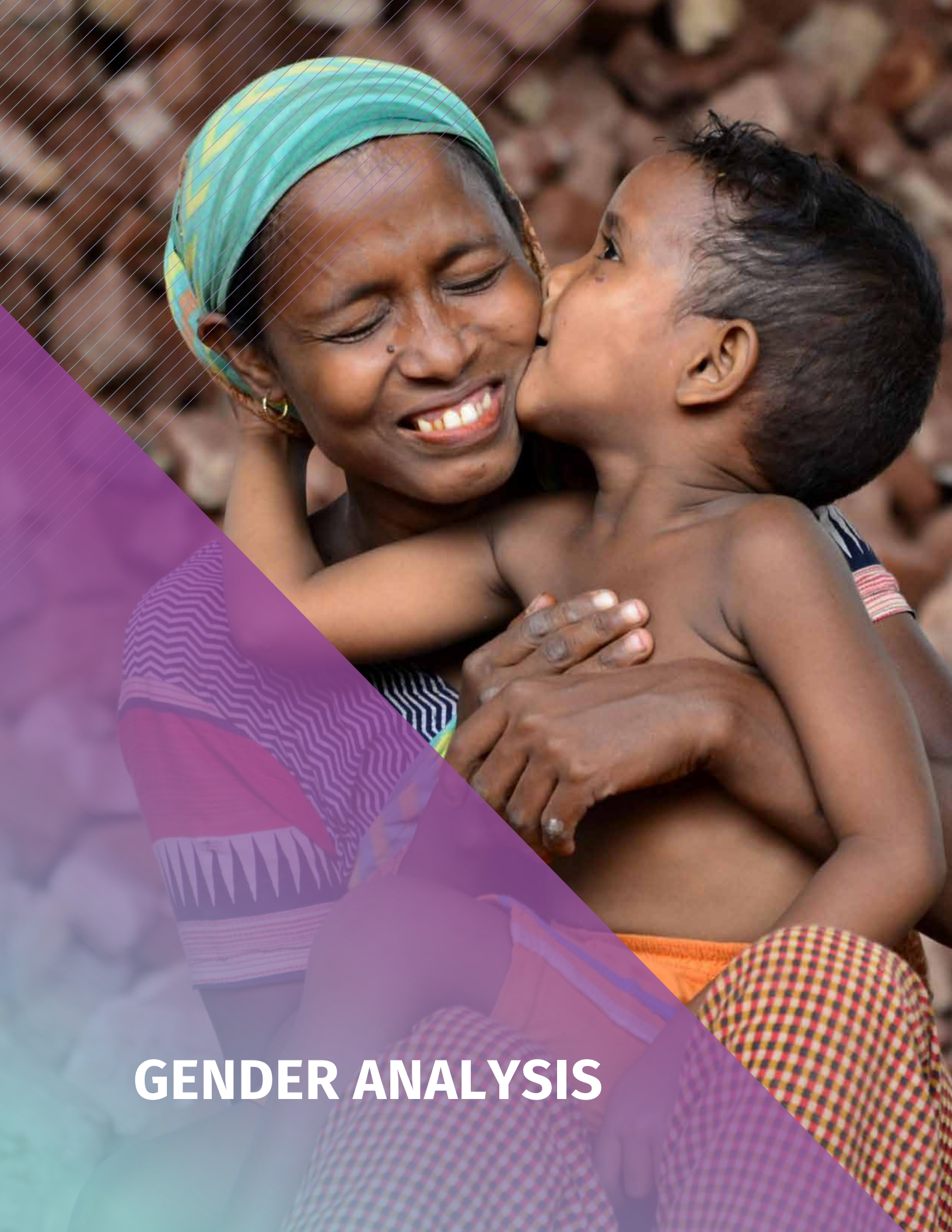
Source: MTF household survey 2017.

There is a relationship between households' access to electricity and their adoption of cooking solutions. Adoption of clean cookstoves is by far highest among those who have a grid connection as the main source of electricity, and lowest among those without access to electricity. Moreover, those in higher MTF tiers (Tiers 4–5) for cooking solutions are mostly found in higher tiers (Tiers 4–5) for electricity access too. These are not coincidences. It is likely that better economic conditions enabled them to adopt improved energy access solutions in both cases. At the same time, it is also likely that access to electricity makes them more amenable to the adoption of clean cooking solutions. After all, it is only reasonable to assume that a household that has grown accustomed to the benefits to smoke-free lighting would appreciate smoke-free cooking, too, without needing much persuasion. Moreover, households can adopt clean cooking appliances such electric rice cookers and induction stoves only if they have electricity.

FIGURE 40 • **Distribution of cooking solutions tier by electricity access tier**



Source: MTF household survey 2017.



GENDER ANALYSIS

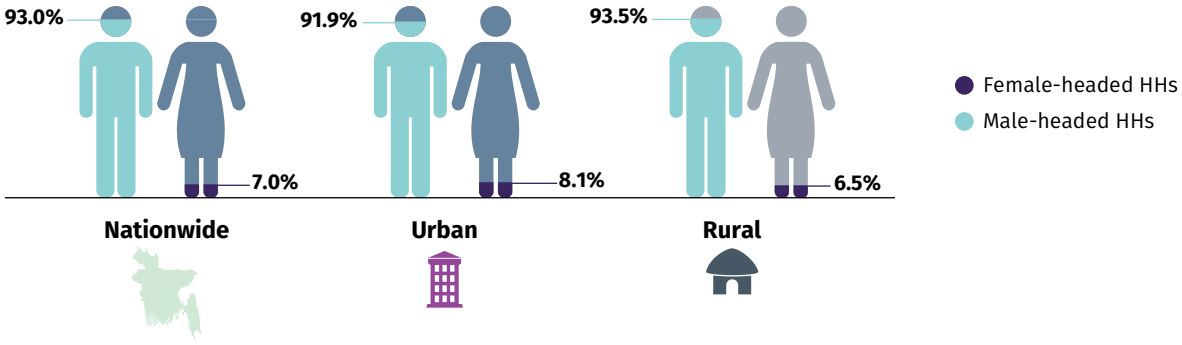
ASSESSING GENDER ANALYSIS

Women usually spend a lot more time at home and are more engaged in household chores than men (ILO 2018; Habimana 2017; Chamie 2018; Haque 2016). The status of energy access at home may have differential impacts on men and women in terms of quality of life, education, and economic welfare. Unfortunately, this is often not taken into consideration in energy intervention projects. As a result, women's traditional responsibilities at home are affected adversely. This is exacerbated when women do not have a say in the decision making on energy access. In the circumstances, it is important to know what roles, if any, women play in household energy-related decisions and how their welfare is affected by household energy access. This also helps us make policies to reduce gender inequality, which is better for the society and the country. In this section, access to energy is examined in terms of the ways it is affected by men's and women's decision making; moreover, any behavioral changes shown by women who may have differential access to energy solutions is examined.

HOW DO HOUSEHOLDS DIFFER BY GENDER OF THE HEAD?

Nationwide, a very large share of the households is male-headed (93%), and there is little variation between urban and rural areas (Figure 41).[42]

FIGURE 41 • **Distribution of male- and female-headed households (HHs)**



Source: MTF household survey 2017.

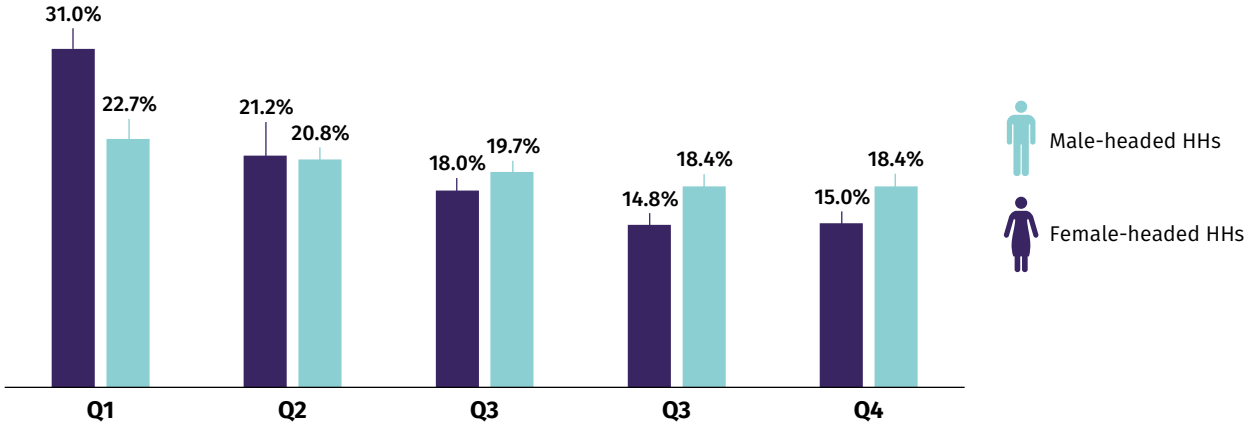
The average age of female and male heads is similar nationwide (49.6 years for females and 48.6 years for males), while female heads are on an average four years older than male heads in

[42] Because of small sample size, some of the disaggregated analysis of female-headed households may have large interval estimates, implying lack of rigor.

urban areas. Male heads tend to have a better education (6.7 years of education completed) compared to female heads (4.7 years) and the difference is wider in urban areas. Female-headed households are slightly smaller than male-headed households (4.1 members for female-headed households versus 4.5 male-headed ones); the size difference increases in rural areas.

Female-headed households are concentrated more in the bottom expenditure quintile (31% versus 22.7% for male-headed households) and less in the highest quintiles (15% for females as opposed to 18.4% for males) (Figure 42). The gap increases in rural areas, with 43.9% of female-headed households falling in the poorest quintile, versus 30.6% of male-headed households.

FIGURE 42 • **Distribution of male- and female-headed households by expenditure quintile**

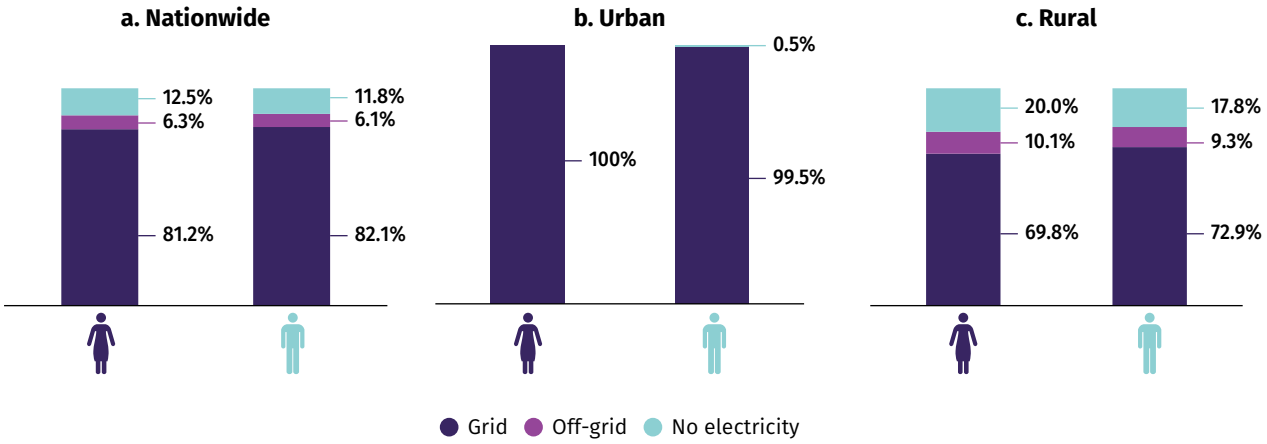


Source: MTF household survey 2017.

ACCESS TO ELECTRICITY

Nationwide, female-headed households are slightly less likely to have access to electricity than male-headed households (87.5% versus 88.2%) (Figure 43). This is mainly due to the lower access of female-headed households to grid electricity in rural areas (69.8% versus 72.9% for male-headed households. Conversely, in urban areas female-headed households reached universal access to the grid (versus 99.5% for male-headed households). Off-grid access is similar for both groups at the national level (at over 6%). In rural areas, female-headed households are slightly more likely to have access to off-grid solutions.

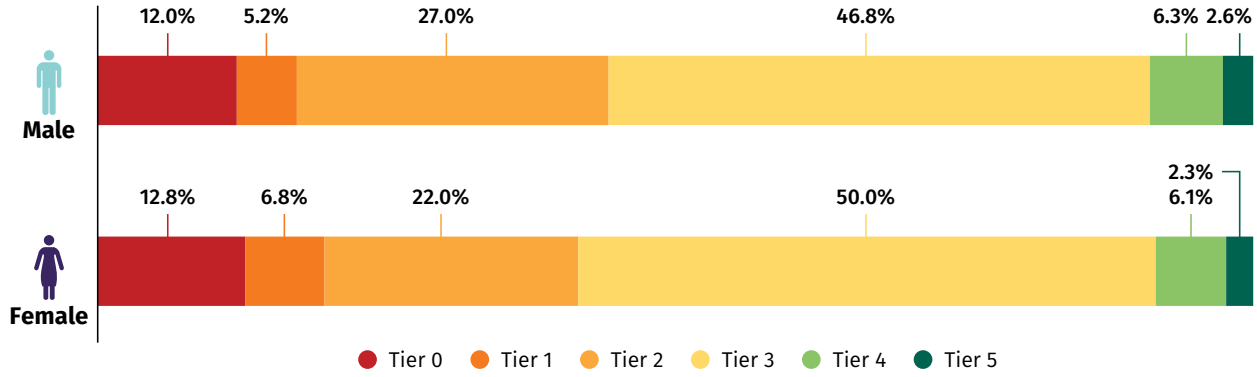
FIGURE 43 • **Main source of electricity by gender of the head**



Source: MTF household survey 2017.

The gendered pattern in binary access to electricity does not change in tiered access. As shown in Figure 44, the share of male-headed and female-headed households is about the same in higher tiers (4 and 5) and in Tier 0. It is only in the middle tiers (2 and 3) that some variations between male- and the female-headed households is observed. However, such difference is not substantial—for example, 47% of the male-headed households, as opposed to 50% of the female-headed households, are in Tier 3. Overall, male- and female-headed households vary little in terms of access to electricity. The pattern does not vary much between rural and urban areas.

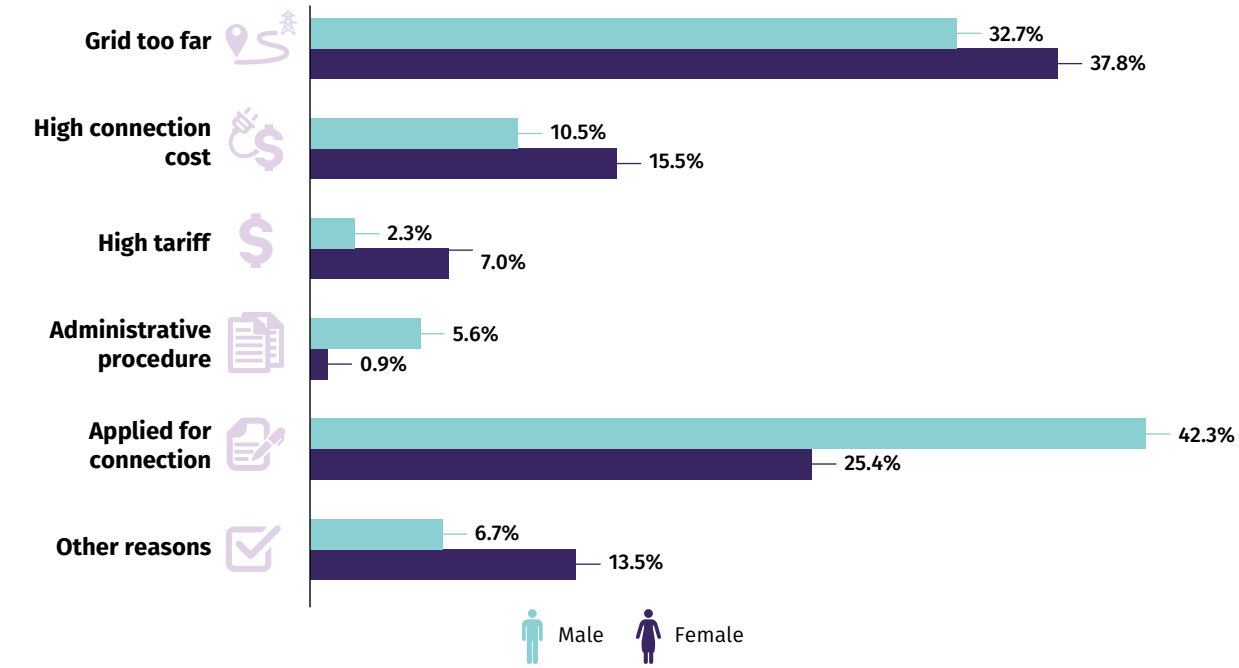
FIGURE 44 • **MTF tier distribution for electricity access by gender of the head**



Source: MTF household survey 2017.

Figure 45 shows that male- and female-headed households vary on why households are not connected to the grid. Female-headed households are more likely than male-headed households to report long distances from the grid, high connection costs, and high tariffs as reasons for not being connected. Male-headed households, on the other hand, are more likely to be in the process of securing a grid connection—42.3% male-headed households as opposed to 25.4% female-headed households applied for grid connection.

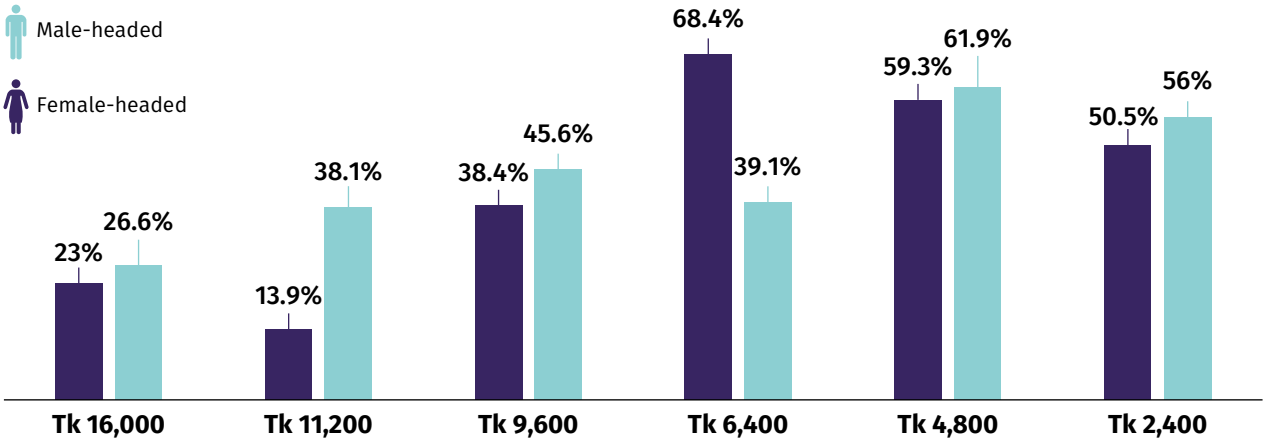
FIGURE 45 • **Reasons for not connecting to grid by male- and female-headed households**



Source: MTF household survey 2017.

Willingness-to-pay for solar home systems (SHSs) by male- and female-headed households was examined for rural households only, since urban households are almost all grid-connected. Figure 46 shows that female-headed households are less willing than male-headed households to buy an SHS unit at higher prices (Tk 9,600 and higher), but more willing to do so at lower prices. In fact, at Tk 6,400, female-headed households are much more willing to buy a unit than are the male-headed households. Overall, female-headed households are less willing to pay for an SHS unit than male-headed households. Regardless of the gender of the head, offering SHSs at subsidized prices or low-cost finance is likely to increase the willingness to adopt an SHS unit.

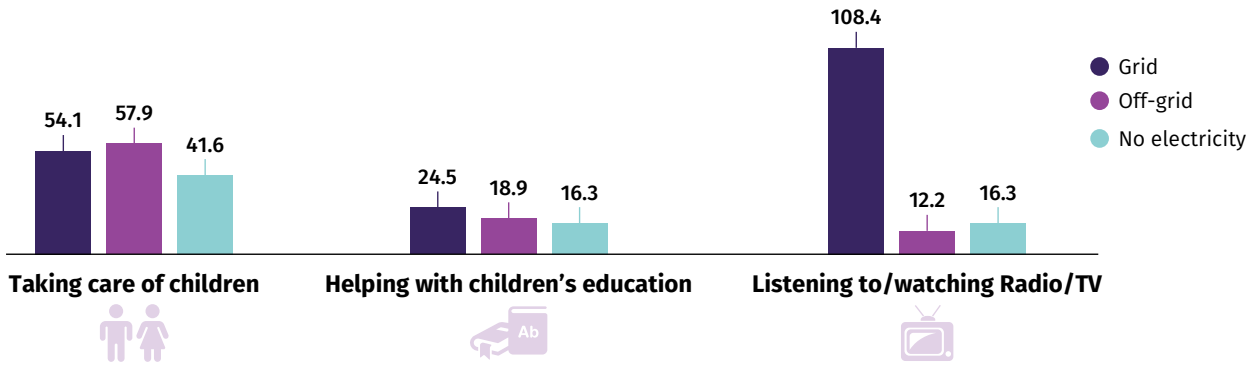
FIGURE 46 • **Share of male- and female-headed households willing to buy SHS units at a given price**



Source: MTF household survey 2017.

Women's time use seems to vary by access to electricity (Figure 47). Those with access to electricity spend more time in general than others taking care of the children, helping the children with studies, and listening to the radio or watching TV.[43] For example, women in households with grid access, off-grid access, and no electricity spend 108 minutes per day, 12 minutes per day, and 16 minutes per day in listening to radio or watching TV, respectively.[44] Moreover, women in households with an SHS spend more time than those in households without access in two of the three activities.

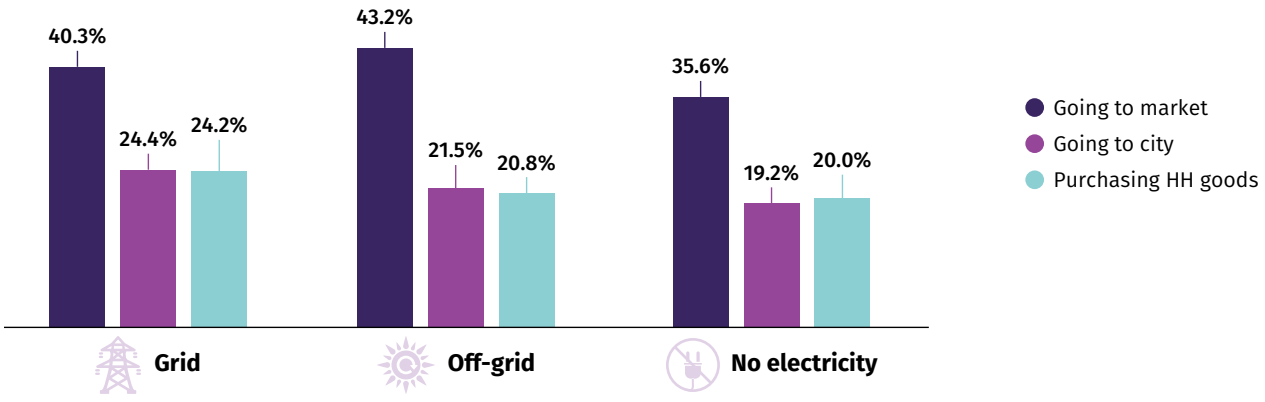
FIGURE 47 • **Women's time use by main source of electricity (minutes per day)**



Source: MTF household survey 2017.

Women in households with a grid connection seem to have more mobility and decision-making ability than their counterparts in households with off-grid access or without access (Figure 48). Forty percent of the women from grid-connected households in rural Bangladesh can go to market places on their own; for women in households with off-grid access or no access, the corresponding figure is 24%. Women in grid-connected households also do better than those in off-grid households or households without access when it comes to going to city or purchasing household goods.

FIGURE 48 • **Women's mobility and decision making by main source of electricity**



Source: MTF household survey 2017.

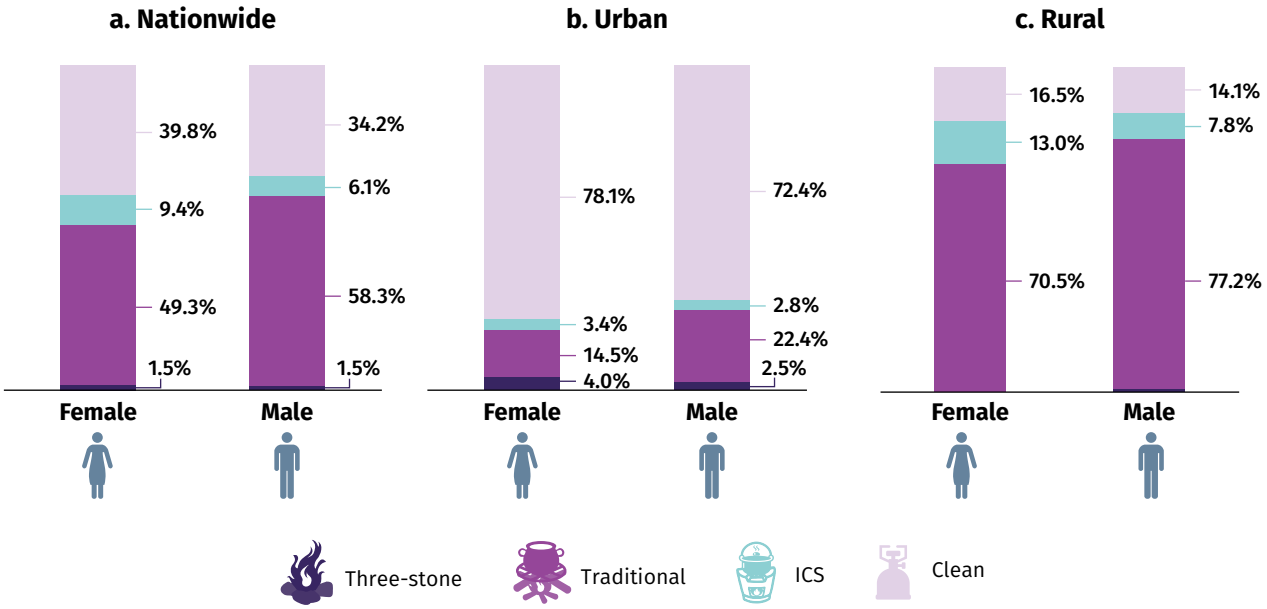
[43] The survey also collected information on women's time in income-generating activities, own studies, and socializing. However, there was no variations in those variables by main source of electricity.

[44] Households without electricity are much less likely to own a radio or a TV (it is not impossible, however, as they can have battery-operated radios or TVs), and accordingly, they do not have much of an option to enjoy those appliances. A benefit of having electricity is that it opens up ways to have entertainment or information access.

ACCESS TO COOKING SOLUTIONS

Unlike access to electricity, access to cooking solutions varies somewhat by gender of the head (Figure 49). Interestingly, female-headed households are more likely to use clean fuel stoves and ICSs than male-headed households, while male-headed households are more likely to use traditional stoves. The trend remains the same in urban and rural areas. In rural areas, the difference in ownership of ICSs is higher (5.2 percentage points) than it is for ownership of clean stoves (2.4 percentage points). In urban areas, on the other hand, the difference is much higher in the ownership of clean cookstoves (about 6 percentage points) than for ownership of ICS (0.6 percentage point).

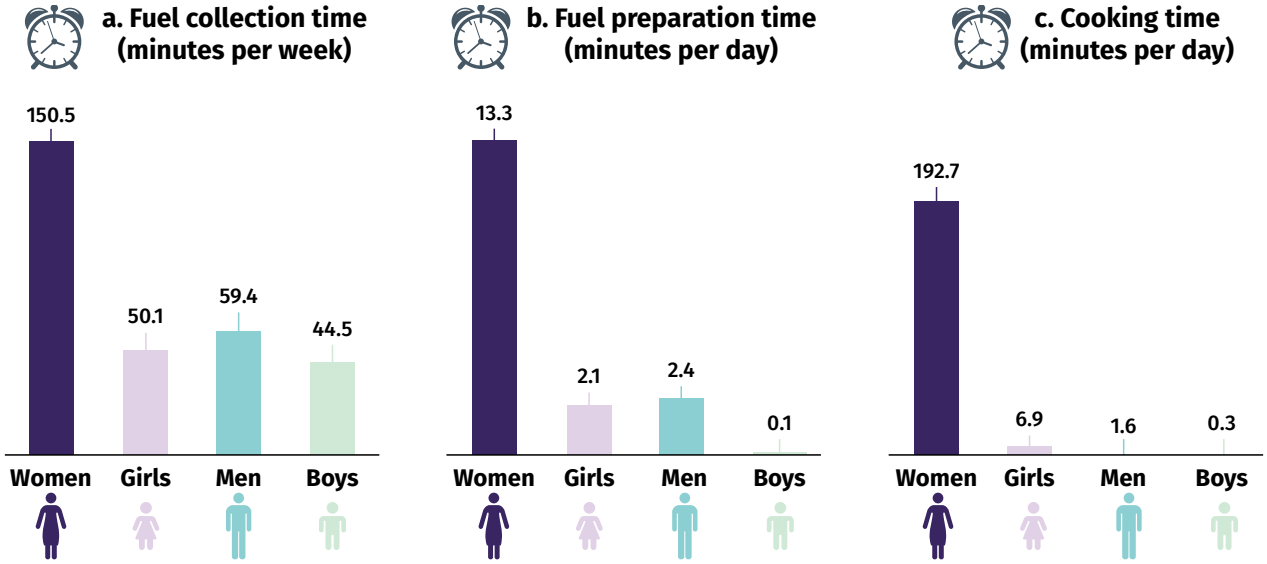
FIGURE 49 • **Main cookstoves by male- and female-headed households**



Source: MTF household survey 2017.

The findings on stove-ownership are not surprising. Since women spend their time most in activities related to cooking—not just in actual cooking, but also in fuel collection and preparation—it is expected that they would like to have improved and clean cookstoves more than males, and being head of the household makes it easier for them to enforce their preferences.

FIGURE 50 • **Time spent in cooking-related activities by household members**

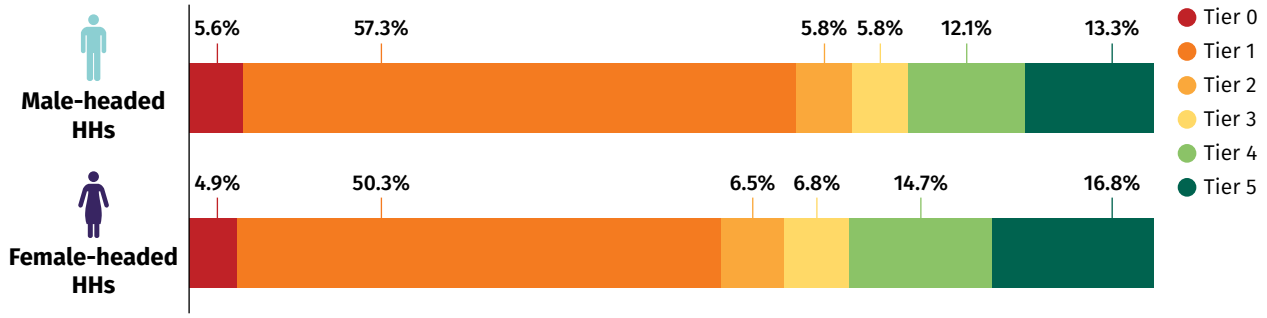


Source: MTF household survey 2017.

Women tend to be the primary cook in the family and spend a much longer time in fuel collection, fuel preparation, and cooking than men, boys and girls (Figure 50).[45] In fact, the time spent in cooking by other members is negligible compared to that by women.[46]

It is expected that stove-ownership pattern by sex of the head will be reflected in the MTF tier distribution of cooking solutions. Figure 51 shows that female-headed households are more likely to fall into higher tiers (Tiers 4–5) than male-headed households (30.5% and 25.4%, respectively), and less likely to be in Tiers 0–1 than male-headed households (55.2% and 62.9%, respectively). The gender gap is higher in urban areas than in rural areas.

FIGURE 51 • **MTF tier distribution of cooking solutions by household head gender**

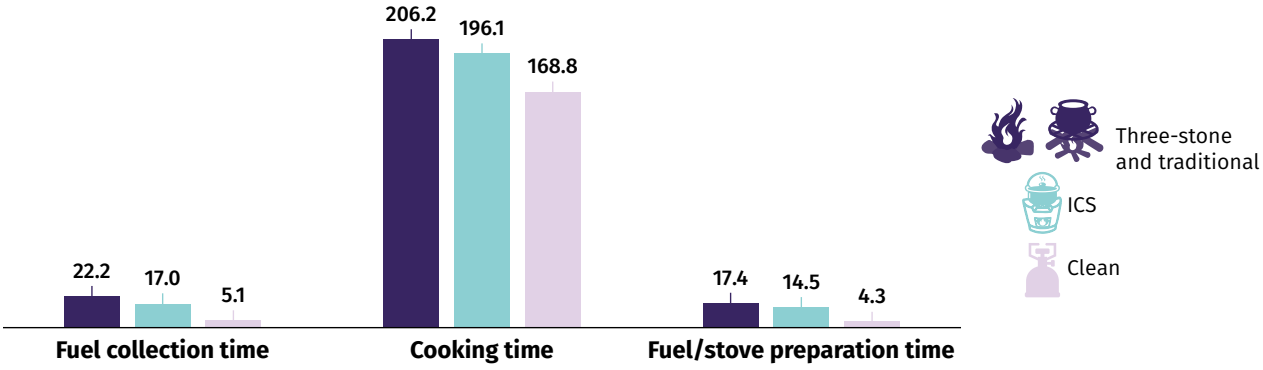


Source: MTF household survey 2017.

[45] According to the MTF survey, women are the main cooks in 93.2 percent of the households.
[46] There is some rural-urban disparity—women in rural areas in general spend more time in these activities than those in urban areas.

Women in households that use a clean cookstove spend a lot less time in fuel collection, fuel and stove preparation, and actual cooking than those in households who use traditional stoves or ICSs, as shown in Figure 52. Women in households with an ICS tend to spend slightly less time in those activities than women in households that use three-stone or traditional stoves exclusively.

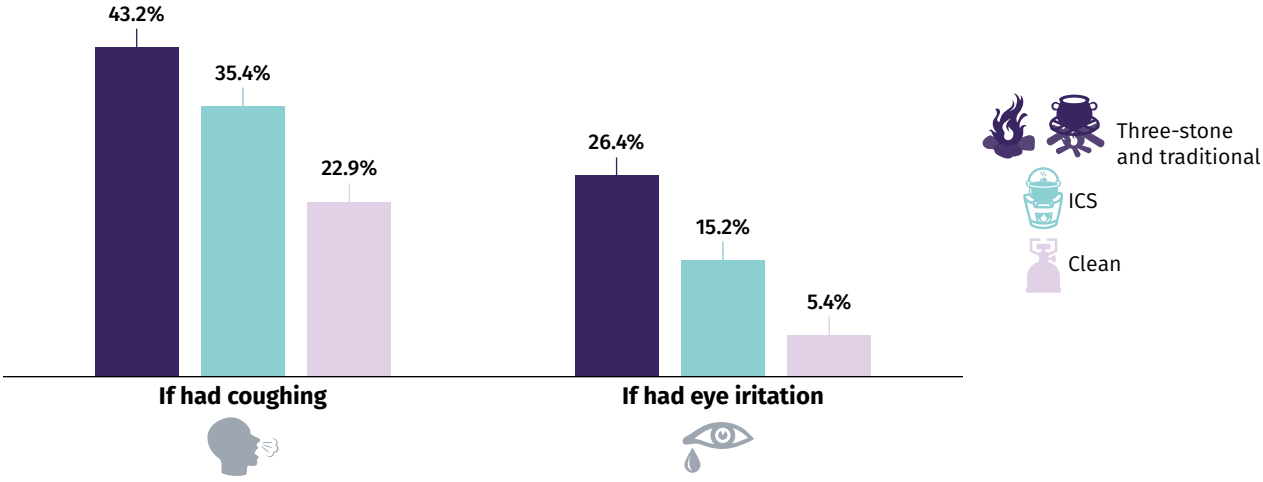
FIGURE 52 • **Women's time spent in activities related to cooking by main cookstove type (minutes per day)**



Source: MTF household survey 2017.

Finally, we find that women in households that use clean cookstoves report less incidence of coughing and eye irritation than those in households that use inferior stoves (Figure 53). More specifically, about 23% women in households with clean cookstoves report having had coughing within two weeks before the survey, while 35% women in households that use an ICS and 43% women in households that use traditional stoves report similar incidence of coughing.

FIGURE 53 • **Incidence of coughing and eye irritation by women by main cookstove type (percent)**



Source: MTF household survey 2017.

It is obvious that female-headed households do better than male-headed households when it comes to modern cooking solutions. And in terms of access to electricity, as we have already seen, female-headed households are closely behind male-headed households or on a par. Women in households with grid-connectivity spend more time in rewarding activities and have more freedom in mobility and decision making than their counterparts in households with off-grid or no access to electricity. Finally, women in households that use clean cookstoves spend less time in cooking or fuel collection and have had less incidence of coughing and eye irritation than those in households that use biomass stoves. While we have not established any causality, such findings are illuminating. This is not to imply that policy makers do not have any role. Policy makers have to ensure that while improving access to modern energy women must not fall behind.

ANNEX 1:
Definitions of Attributes and Tiers for Access to Electricity

ATTRIBUTE		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Capacity	Power capacity ratings (W or daily Wh)	Less than 3 W	At least 3 W	At least 50 W	At least 200 W	At least 800 W	At least 2 kW
		Less than 12 Wh	At least 12 Wh	At least 200 Wh	At least 1 kWh	At least 3.4 kWh	At least 8.2 kWh
	Services		Lighting of 1,000 lmhr per day	Electrical lighting, air circulation, television, and phone charging are possible			
Availability	Daily Availability	Less than 4 hours	At least 4 hours and less than 8 hours	At least 4 hours and less than 8 hours	At least 8 hours and less than 16 hours	At least 16 hours and less than 23 hours	At least 23 hours
	Evening Availability	Less than 1 hour	At least 1 hour and less than 2 hours	At least 2 hours and less than 3 hours	At least 3 hours and less than 4 hours	4 hours	4 hours
Reliability		More than 14 disruptions per week				(More than 3 and up to 14 disruptions per week) or less than or equal to 3 disruptions per week with more than 2 hours of outage	At most 3 disruptions per week with total duration of less than or equal to 2 hours
Quality		Voltage problems does damage to appliances				Voltage problems do not affect the use of appliances	
Affordability		Cost of a consumption package of 365 kWh per year is more than or equal to 5% of household income			Cost of a consumption package of 365 kWh per year is less than 5% of household income		
Formality		Bill is not paid				Bill is paid to the utility, prepaid card seller, or authorized representative	
Health and Safety		Electricity-related accidents in last one year				No electricity-related accidents in last one year	

Note: Tiers are color-coded, not column-bound. For example, yellow represents Tier 3 regardless of column location. The attributes of Reliability, Quality, Affordability, Formality, and Health and Safety apply to grid or mini-grid electricity only.

ANNEX 2:
Definitions of Attributes and Tiers for Access to Cooking Solutions

ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Cooking Exposure	**Emission** Stove desi SO's voluntary performance targets (Default Ventilation) PM2.5 (mg/MJd) CO (g/MJd) gn	>1030 >18.3	≤1030 ≤18.3	≤481 ≤11.5	≤218 ≤7.2	≤62 ≤4.4	≤5 ≤3.0
	High Ventilation PM2.5 (mg/MJd) CO (g/MJd)	>1489 ≥26.9	≤1489 ≤26.9	≤733 ≤16.0	≤321 ≤10.3	≤92 ≤6.2	≤7 ≤4.4
	Low Ventilation PM2.5 (ng/MJd) CO (g/MJd)	>550 >9.9	≤550 ≤9.9	≤252 ≤5.5	≤115 ≤3.7	≤32 ≤2.2	≤2 ≤1.4
Cookstove Efficiency	ISO's voluntary performance Targets	≤10%	>10%	>20%	>30%	>40%	>50%
Convenience	Fuel acquisition and preparation time (hours per week)	≥7		<7	<3	<1.5	<0.5
	Stove preparation time (minutes per meal)	≥15		<15	<10	<5	<2
Safety		Serious Accidents over the past 12 months				No serious accidents over the past year	
Affordability		Fuel cost ≥5% of household expenditure (income)				Fuel cost <5% of household expenditure (income)	
Fuel availability		Primary fuel available less then 80% of the year				Available 80% of the year	Readily available throughout the year

Source: World Bank 2015.
Note: Colors signify tier categorization.

REFERENCES

Akpalu, Wisdom, Isaac Dasmani, and Peter B. Aglobitse. 2011. "Demand for Cooking Fuels in a Developing Country: To What Extent Do Taste and Preferences matter?" *Energy Policy* 39 (10): 6525–31.

BMP (Bangladesh Ministry of Power, Energy and Mineral Resources, Power Division). 2016. *Power System Master Plan 2016.* Dhaka: Ministry of Power, Energy, and Mineral Resources.

Bhatia, Mikul, and Angelou, Niki. 2015. *Beyond Connections: Energy Access Redefined*. ESMAP Technical Report 008/15. Washington, DC. World Bank. https://openknowledge.worldbank.org/handle/10986/24368.

Blackden, M., and Q. Wodon. 2006. "Gender, Time Use, and Poverty in Sub-Saharan Africa." Discussion Paper No. 73, World Bank, Washington, DC.

Chamie, Joseph. 2018. "Despite Growing Gender Equality, More Women Stay at Home Than Men." *YaleGlobal Online*. January 25. https://library.dctabudhabi.ae/eds/detail?db=asn&an=127587937.

Clancy, J. S., M. Skutsch, and S. Bachelor. 2003. "The Gender-Energy-Poverty Nexus: Finding the Energy to Address Gender Concerns in Development." DFID Project CNTR998521. London: Department for International Development.

Ekouevi, K., and V. Tuntivate. 2012. *Household Energy Access for Cooking and Heating: Lessons Learned and the Way Forward.* Washington, DC: World Bank.

ESMAP (Energy Sector Management Assistance Program), 2004. *The Impact of Energy on Women's Lives in Rural India.* Washington, DC: ESMAP/World Bank.

Gwavuya, S. G., S. Abele, I. Barfuss, M. Zeller, and J. Müller. 2012. "Household Energy Economics in Rural Ethiopia: A Cost-benefit Analysis of Biogas Energy," *Renewable Energy* 48: 202–209.

Habimana, O. 2017. "Gender Differences in Time Allocation: Evidence from Rwanda." Turin School of Development Working Paper 8. International Training Centre of the ILO, Turin, Italy.

Haque, Tanya. 2016. "Exploring Uncounted Contribution of Women in Bangladesh: Barriers, Implications and Opportunities." *Advances in Diabetes and Metabolism* 4 (4): 85–97.

ILO (International Labour Organization). 2018. *Care Work and Care Jobs: For the Future of Decent Work.* Geneva: ILO.

Jürisoo, Marie, Fiona Lambe, and Mathew Osborne. 2018. "Beyond Buying: The Application of Service Design Methodology to Understand Adoption of Clean Cookstoves in Kenya and Zambia." *Energy Research and Social Science* 39 (May): 164–176.

Khandelwal, Meena, Matthew Hill, Paul Greenough, Jerry Anthony, Misha Quill, Marc Linderman, and H. S. Udaykumar. 2017. "Why Have Improved Cook-Stove Initiatives in India Failed?" *World Development* 92 (April): 13–27.

Lipton, M. 1988. *The Poor and the Poorest: Some Interim Findings*. Washington, DC: World Bank. http://documents.worldbank.org/curated/en/424871468765924001/pdf/multi-page.pdf.

Millar, Grant, and A. Mushfiq Mobarak. 2013. "Gender Differences in Preferences, Intra-Household Externalities, and Low Demand for Improved Cookstoves." *NBER Working Paper* 18964 (April), National Bureau for Economic research, Cambridge, MA: 13–27.

O'Neill, Jim, and Anna Stupnytska. 2009. "The Long-term Outlook for the BRICs and N-11 Post Crisis." *Global Economics Paper* 192. Goldman Sachs, New York. https://www.goldmansachs.com/insights/archive/brics-at-8/brics-the-long-term-outlook.pdf.

Parikh, J. 2011. "Hardships and Health Impacts on Women Due to Traditional Cooking Fuels: A Case Study of Himachal Pradesh, India." *Energy Policy* 39 (12): 7587–7594

Ouedraogo, Boukary. 2006. "Household Energy Preferences for Cooking in Urban Ouagadougou, Burkina Faso." *Energy Policy* 34 (18): 3787–95.

Power Cell. 2018. *Glimpses of Bangladesh Power Sector: A Success Story*. Dhaka: Ministry of Power, Energy, and Mineral Resources.

Ray, Charlotte, Mike Clifford, and Sarah Jewitt. 2014. "The Introduction and Uptake of Improved Cookstoves: Making Sense of Engineers, Social Scientists, Barriers, Markets and Participation." *Boiling Point* 64: 2–5.

Rehfuess, Eva, Sumi Mehta, and Annette Prüss-Üstün. 2006. "Assessing Household Solid Fuel Use: Multiple Implications for the Millennium Development Goals." *Environmental Health Perspectives* 114 (3): 373–378.

Rosenbaum, Julia, Elisa Derby, and Karabi Dutta. 2015. "Understanding Consumer Preference and Willingness to Pay for Improved Cookstoves in Bangladesh." *Journal of Health Communication* 20 (Sup1): 20–27.

UNDP (United Nations Development Programme) and WHO (World Health Organization). 2009. *The Energy Access Situation in Developing Countries: A Review Focusing on the Least Developed Countries and Sub-Saharan Africa*. New York: UNDP and WHO.

Wang, X., J. Franco, O. R. Masera, K. Troncoso, and M. X. Rivera. 2013. *What Have We Learned about Household Biomass Cooking in Central America?* ESMAP Report No. 76222. Washington, DC: ESMAP/World Bank.

World Bank. 2011. *Household Cookstoves, Environment, Health, and Climate Change: A New Look at the Old Problem*. Washington, DC: World Bank

World Bank. 2013. *Global Tracking Framework*. Washington, DC: Sustainable Energy for All, World Bank.

World Bank. 2018. *Policy Matters: Regulatory Indicators for Sustainable Energy*. Washington, DC: World Bank.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