MYANMAR

Beyond Connections

Energy Access Diagnostic Report Based on the Multi-Tier Framework

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MTF Multi-Tier FRAMEWORK

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This Energy Access Diagnostic Report details the results of the MTF survey in Myanmar and provides the status of access to electricity and access to modern energy cooking solutions in that country. The 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

CFL	Compact Fluorescent Lights
ESMAP	Energy Sector Management Assistance Program
ICS	Improved Cookstove
GDP	Gross Domestic Product
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-Emitting Diode
LPG	Liquefied Petroleum Gas
MMK	Myanmar Kyats
MTF	Multi-Tier Framework
MW	Megawatts
NEP	National Electrification Plan
PSU	Primary Sampling Unit
SHS	Solar Home System
SLS	Solar Lighting System
W	Watt
WTP	Willingness To Pay

EXECUTIVE SUMMARY

With a population of close to 54 million, Myanmar has become one of Asia's most rapidly growing economies, showing a 6.4% growth rate in gross domestic product (GDP) in 2016–17 and successfully reducing the poverty rate by 18.4% between 2004 and 2015[1]. These noteworthy accomplishments are in line with the government's substantial effort to achieve the Sustainable Development Goal on energy access (target 7.1), which aims at "ensuring access to affordable, reliable, and modern energy for all."

ACCESS TO ELECTRICITY

Among households, 86.5% have access to at least one source of electricity; 38.6% have access through the national grid; and 48.0% have access through off-grid solutions, including the 11.4% that have access through a solar home system (SHS), which can power a television or a fan (see Table 1). Approximately 20% of households use a solar lantern or solar lighting system (SLS), which can typically provide only lighting or charging mobile phones. Respectively, 9.2% and 7.9% of households use rechargeable batteries or rely on mini-grids.

Off-grid solutions play a critical role in supplying electricity to those without access to the grid. They are more prevalent in rural areas, where the gap in access to the grid is wide: 61.1% of rural households and 11.0% of urban households use off-grid energy solutions; 85.3% of urban households and 22% of rural households have access to the grid.

The Multi-Tier Framework (MTF) defines access to electricity as the spectrum ranging from Tier 0 (no access) to Tier 5 (full access) through seven attributes: Capacity, Availability, Reliability, Quality, Affordability, Formality, and Health and Safety.[2] In Myanmar, 29.7% of households are in Tier 0, while about 70.3% have access to at least Tier 1 electric services. Households are in Tier 0 because they have either no access to electricity (13.5%) or access to some sort of electricity that does not meet the minimum requirement for Tier 1 service (16.2%).

Shifting Tier 0 households to higher tiers (Tier 1+) is critical for improving the status of electricity access in Myanmar. Moving Tier 0 households to a higher tier will require connecting these households to the grid—grid densification or extension—or providing them with off-grid solutions such as standalone solar solutions or mini-grids.

1 Myanmar Poverty Assessment 2017 (http://www.worldbank.org/en/country/myanmar/publication/myanmar-poverty-assessment-2017-part-one-examination-of-trends)

2 For descriptions of the MTF and its attributes, see Annex 1.

A major barrier preventing households from gaining a grid connection is the up-front cost. To lessen the upfront financial burden of gaining this connection, a **payment plan option (or sources of financing), such as microfinance, should be considered while also being mindful of other direct costs associated with gaining the connection, such as internal wiring**. Off-grid solar products could help households in villages not yet reached by the grid infrastructure. **Strengthening the quality control framework, coupled with microfinance or leasing opportunities, could expand the adoption of solar devices.** The quality control framework includes evaluating, comparing, and disseminating information on product quality and performance. A **consumer awareness program would enable potential customers to choose good-quality products and use them more sustainably**. Along with the expansion of off-grid solar solutions, **the role of mini-grids should be increased in areas where mini-grids are the optimal, cost-efficient energy solution.**

Almost all grid-connected households in Myanmar (98.6%) are in Tiers 3–5. More than half (57.2%) of households in the top expenditure quintile are connected to the grid, which is in great contrast to the 18.3% of grid-connected households in the lowest expenditure quintile. The average monthly electricity consumption in Myanmar is 132 kilowatt-hours, and urban households consume twice as much as rural consumers (169 kilowatt-hours and 82 kilowatt-hours a month, respectively). Urban households have been connected to the national grid for an average of seven years, while rural households have been connected for three years (a median value). The largest share of grid-connected households (17.2%) is in Tier 4, followed by Tier 5 (12.9%) and Tier 3 (7.5%). Improvements in Reliability (Interruption) and quality (voltage fluctuation) could potentially shift 24.7% of Myanmar households—7.5% from Tier 3 and 17.2% from Tier 4—up to Tier 5.

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

Almost half the households in Myanmar use three-stone stoves exclusively (45.6%).[3] The remaining households use traditional stoves (12.8%), improved cookstoves (ICSs) (15.4%), electric stoves (12%), or liquefied petroleum gas (LPG) stoves (0.8%). Most households use only one type of stove, but 13% rely on multiple stove types to meet their cooking needs.

A significant gap exists between rural and urban households in access to modern energy cooking solutions. More than one-third of urban households (33.8%) use electric stoves exclusively. This combined with the 22.4% of urban households that use electric stoves in combination with biomass stoves results in a total of 56.2% of urban households using an electric stove either as the main stove or a supplementary stove. The exclusive use of improved stoves is also common in urban areas (21.8%). Fewer than 10.0% of urban households use LPG stoves either exclusively (2.6%) or in combination with electric stoves (3.4%). In rural areas where firewood is a more common fuel, 58.0% of households use three-stone stoves; 15.9% use traditional stove; and 13.2% use improved stoves. In rural areas, 7.5% of households use electric stoves, along with biomass stoves, while a mere 4.5% use electric stoves exclusively.

The MTF measures the access to modern cooking energy solutions. It ranges from Tier 0 (no access) to Tier 5 (full access) through six attributes: Cooking Exposure, Cooking Efficiency, Convenience, Availability

3 The three-stone stove consists of three stones of approximately the same height on which a pot may rest over a fire built amid the stones.

of fuel, Affordability, and the Safety of the Primary Cookstove. (For a comprehensive description of the MTF and its attributes, see Access to Modern Energy Cooking Solutions section.) More than half (57.1%) of households in Myanmar are in Tier 0 for access to modern energy cooking solutions; 16.4% are in Tiers 4–5, even though 23.5% of households use clean fuel stoves as their primary stoves. The discrepancy mainly arises because these latter households use their clean fuel stoves in combination with biomass stoves, a behavior that dilutes the benefits of using clean fuel stoves. Many households that use biomass stoves are classified in a lower tier because of the Cooking exposure attribute: they cook with stoves that produce fumes in poorly ventilated spaces. Most households in Tiers 4 and 5 use clean fuel stoves exclusively or more frequently than biomass stoves.

Given the important health benefits of using clean fuels for cooking, **the government should explore ways to increase the adoption of clean fuel stoves, particularly electric stoves and LPG stoves.** Because of the substantial penetration of electric stoves and the low price of electricity, along with the expansion of the grid, the share of households relying on electric stoves may increase. The rising demand for electricity associated with cooking should be considered in planning for electricity generation and network expansion. The promotion of the use of more efficient electric stoves is also recommended.

Another clean fuel stove option is the LPG stove. The current rate of adoption is low, and the barriers to wider LPG stove adoption should be investigated. As LPG stoves become more widely available and affordable, households, especially those without grid-connection, may consider them an appealing clean cookstove option. Were the electricity tariff to increase, availing more clean cooking solutions such as the LPG stove, would help convince electric stove users to avoid falling back into reliance on biomass stoves.

Promoting the use of an improved cookstove (ICS) is a promising solution for households in Tiers 0 and 1 that use three-stone or traditional stoves and are unlikely to be able to afford clean fuel stoves. Households that switch from three-stone stoves or traditional stoves to an ICS will save on the time they now use to collect fuel by 32%–52%. Households cooking with three-stone stoves or traditional stoves spend an average of 10.4 hours and 7.4 hours a week, respectively, on collecting cooking fuel, while households using ICS spend 4.9 hours a week.

To increase the adoption of an ICS, the issue of the high up-front cost should be addressed. Households that use three-stone or traditional stoves tend to be in the in lower-income quintiles. **Offering installment plans may be an effective way to increase the adoption of the ICS. Enhancing public awareness on the benefits of using improved biomass stoves rather than three-stone or traditional stoves is likewise important.**

Advanced biomass stoves, which contribute less to indoor air pollution and thus can have positive health benefits, are also a promising solution. Barriers to the adoption of advanced biomass stoves are the high up-front cost and the lack of public awareness of the benefits of advanced biomass stoves. **Explaining the health benefits of advanced biomass stoves and making the cost of advanced biomass stoves more affordable by, for example, offering payment plans or targeted subsidies could increase the penetration of these stoves. Public awareness campaigns would educate households on ways to improve ventilation, effectively minimizing the hazards associated with exposure to indoor air pollution.**

GENDER

In Myanmar, female household heads are less well educated than male household-heads. More than a quarter of female household heads (27.3%) have never attended school, compared with 10.4% of male-headed households. Moreover, female household heads tend to be in lower expenditure quintiles relative to their male counterparts: 47% of female-headed households are in the bottom 40% of the expenditure distribution (the bottom 40), compared with 38.5% of male-headed households.

Access to electricity. More female-headed households in rural areas have no access to electricity (21%) relative to male-headed households (16%). Findings show a correlation between the use of electricity and household expenditure level, revealing that more female-headed households are in lower-expenditure quintiles relative to male-headed households; this gap is especially evident in rural areas.

Relative to male-headed households in the same income quintile, female-headed households are less willing to pay for a grid connection or for off-grid solar solutions. **Thus, it may be beneficial to provide targeted subsidies for vulnerable people to address the high up-front costs of stand-alone solar products.**

Access to modern energy cooking solutions. No significant difference exists in the aggregate cooking tier distribution between male- and female-headed households in urban or rural areas. In urban areas, 43.0% and 43.1% of male- and female-headed households, respectively, are in Tier 5 because more households in urban areas use either electric or LPG stoves as the primary stove. In rural areas, more than half of male- and female-headed households are in Tier 0 because they use either three-stone or traditional stoves that have the emissions of Tier 0 stoves.

Regardless of the gender of the household head, more than half the households that use three-stone or traditional stoves exhibit little willingness to pay (WTP) for an ICS. Offering a longer repayment plan could help increase the adoption of an ICS. At full price (36,000 MMK or 26 USD)[4], more female-headed households (77.9%) show reluctance to pay regardless of the payment plan options relative to man-headed households (64.5%). However, at the lower price options, no significant difference in response is observed among male- and female-headed households.

Female household members, particularly those ages 15 or above, spend significantly more time cooking compared with their male counterparts. When using three-stone stoves, female adults, on average, spend more than 137 minutes a day in the cooking space, compared with less than 13 minutes among males. In addition, women in households with clean cookstoves save 29 minutes a day in cooking relative to women in households with open-fire stoves. Thus, the greater adoption and use of modern energy cooking solutions would help reduce the time spent in the cooking space; women would also reap the benefits of the positive health impacts of reducing their exposure to indoor air pollution, if the household upgrades their cookstove type or adopts better cooking practices, that is, improving ventilation.

4 Note: The average exchange rate between May 1, 2017, and July 1, 2017 was 1 U.S. dollar = 1363 MMK.

MEASURING ENERGY ACCESS IN MYANMAR

Gaining access to energy is not the end, but the means to many ends. Energy is vital to promoting economic growth, overcoming poverty, and facilitating human development. Target 7.1 of the Sustainable Development Goal on energy access aims at "ensuring access to affordable, reliable, and modern energy for all." The government of Myanmar has been committed to achieving Sustainable Development Goal 7 to benefit the people of Myanmar. The government has thus collaborated with the World Bank to realize the Multi-Tier Framework (MTF) survey to obtain guidance on setting targets, policies, and investment strategies for enhancing energy access.

Myanmar has become one of Asia's most rapidly growing economies. The growth rate of gross domestic product (GDP) was 6.4% in 2016/17 and is expected to reach 7.0% by 2019/20. Myanmar is mostly a lower-middle-income country; its economy is driven by agriculture and services. The poverty rate was reduced by 18.4% between 2004 and 2015 (World Bank 2017). The electrification rate has risen substantially (Box 1). According to *Tracking SDG7: The Energy Progress Report 2018* (World Bank 2018a), 49% of the population had access to electricity in 2010, and the share had increased to 52% by 2014.[5] As of 2017, 86.6% of households in Myanmar had at least one source of electricity according to the MTF survey. The MTF results are consistent with historical trends in electrification in Myanmar.

THE MULTI-TIER FRAMEWORK GLOBAL SURVEY

The World Bank, with the support of the Energy Sector Management Assistance Program (ESMAP), has launched the Global Survey on Energy Access, which relies on the MTF approach. The first phase is being carried out in 17 countries across Latin America, Africa and Asia including Myanmar. The survey's objective is to provide more nuanced data on energy access, including access to electricity and cooking solutions. The MTF approach goes beyond the traditional binary measurement of energy access—for example, having or not having a connection to electricity and using or not using clean fuels in cooking—to capture the multidimensional nature of energy access and the vast range of technologies and sources that can provide energy access, while accounting for the large differences in user experiences.[6]

The MTF approach measures energy access provided by any technology or fuel based on a set of attributes that capture key characteristics of the energy supply that affect the user experience. Based on these attributes, the MTF includes six tiers of access, ranging from Tier 0 (no access) to Tier 5 (full access), along with a continuum of improvement. Each attribute is assessed separately. The overall tier measuring a household's access to electricity is the lowest applicable tier attained among the attributes (Bhatia and Angelou 2015).

5 Based on census data, the electrification rate covers electricity supplied through the public grid, water mills, and solar power systems.

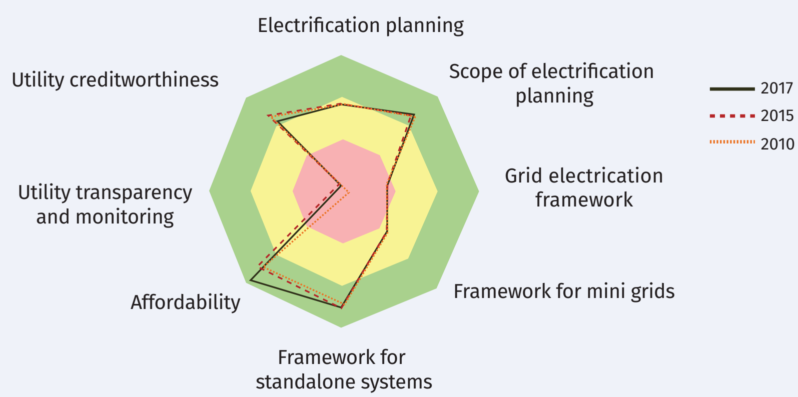
6 The MTF access rate includes access provided by off-grid technologies, which is often excluded by the binary rate, but excludes grid connections that do not meet the MTF criteria for a minimum level of service.

7 RISE results for Myanmar can be viewed at: http://rise.worldbank.org/country/myanmar

BOX 1 • SUMMARY OF ELECTRICITY ACCESS INDICATORS, REGULATORY INDICATORS FOR SUSTAINABLE ENERGY (RISE) MYANMAR

The government of Myanmar has had a policy framework for electrification since 2010. There were major policy advances between 2010 and 2015 when the government developed electrification plans and frameworks for grid electrification, minigrids, and stand-alone systems. The government approved the National Electrification Plan in 2015. The scope of the electrification plan is broad. The plan covers service targets and off-grid solutions and contains provisions on productive services, gender sensitivity, and energy access among people in informal settlements. Utilities are considered creditworthy, and electricity connections and the supply of subsistence electricity are affordable. However, there have been no other major policy improvements since 2015, except for policies making electricity connections and the supply of subsistence electricity affordable. Policies on the grid electrification framework, the mini-grid framework, and the transparency and monitoring of the electricity utility need to be improved.

FIGURE B1.1 • **Trends in Indicators on Access to Electricity, Myanmar, 2010, 2015, and 2017**



Source: World Bank 2018c

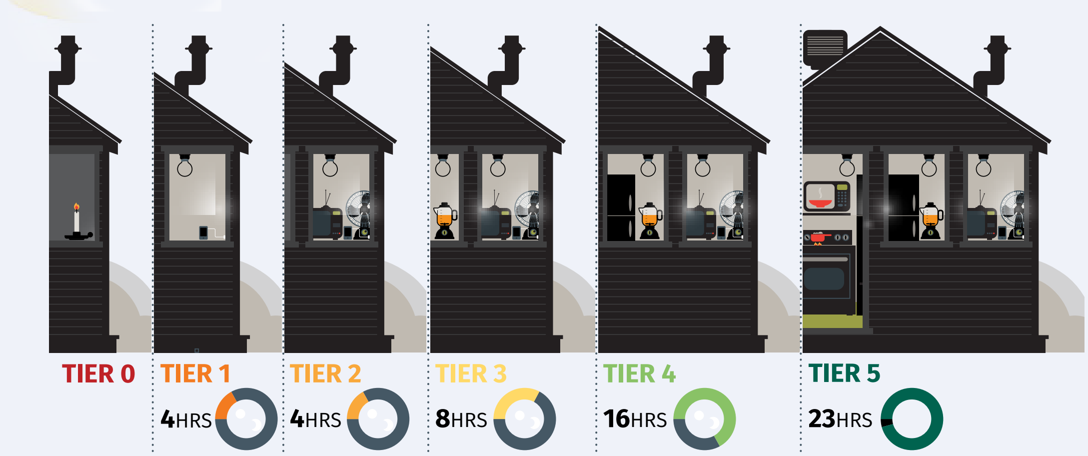
ACCESS TO ELECTRICITY

Access to electricity is measured based on seven attributes: Capacity, Availability, Reliability, Quality, Affordability, Formality, and Health and Safety (see Annex 1). Tier 0 refers to households that receive electricity for less than four hours a day (or less than one hour per evening) or that have a primary energy source with a capacity of less than 3 watts. (See Box 2 for the minimum requirements, by tier of electricity access.) Tier 1 refers to households with limited access to small quantities of electricity provided by any technology, even a small solar lighting system (SLS), for a few hours a day, enabling electric lighting and phone charging. (See Box 3 for a typology of off-grid solar devices.)

BOX 2 • MINIMUM ELECTRICITY REQUIREMENTS, BY TIER OF ELECTRICITY ACCESS

MEASURING ENERGY ACCESS: THE TIERS

Improving attributes of energy supply leads to higher tiers of access.



Tier 0	Tier 1	Tier 2
Electricity is not available or is available for less than four hours a day (or less than one hour per evening). Households cope by using candles, kerosene lamps, or battery-powered devices, such as flashlights and radios.	Electricity is available for at least four hours a day, including at least one hour per evening, and the capacity is sufficient to power task lighting and phone charging or a radio. Sources that can be used to meet these requirements include an SLS, a solar home system (SHS), a mini-grid (a small-scale, isolated distribution network that provides electricity to local communities or a group of households), and the national grid	Electricity is available for at least four hours a day, including at least two hours per evening, and capacity is sufficient to power low-load appliances as needed during that time, such as multiple lights, a television, or a fan (see Table 1). 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
Electricity is available for at least eight hours a day, including at least three hours per evening, and capacity is sufficient to power medium-load appliances as needed during that time, such as a refrigerator, freezer, food processor, water pump, rice cooker, or air cooler (see Table 1). In addition, the household can afford a basic consumption package of 365 kilowatt-hours per year. Sources that can be used to meet these requirements include an SHS, a generator, a mini-grid, and the national grid.	Electricity is available for at least 16 hours a day, including at least four hours per evening, and capacity is sufficient to power high-load appliances as needed during that time, such as a washing machine, iron, hairdryer, toaster, and microwave. There are no long or frequent 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 diesel-based mini-grids and the national grid.	Electricity is available for at least 23 hours a day, including 4 hours per evening, and capacity is sufficient to power very high load appliances as needed during that time, such as air conditioners, space heaters, vacuum cleaners, and electric stoves. The most likely source for meeting these requirements is the national grid, though a generator or mini-grid might suffice as well.

Source: Bhatia and Angelou 2015

BOX 3 • TYPOLOGY OF OFF-GRID SOLAR DEVICES AND TIER CALCULATION

Solar devices are classified into three types based on the number of lightbulbs and the type of appliances or services a household uses. This typology is used to assess the Capacity attribute and the related tier.

Solar lanterns power a single lightbulb and allow only part of the household to be classified in Tier 1. Under the MTF methodology, the number of household members in Tier 1 is based on the light output (lumen-hours) and phone charging capability of the solar lantern.

Solar Lighing System (SLS) power two or more lightbulbs and allow part or all the household to be classified in Tier 1.

Solar home systems (SHSs) power two or more lightbulbs and appliances such as televisions, irons, microwaves, or refrigerators. (See Table 1 for the load level associated with each tier.)

TABLE 1 • Appliances by load level, and associated Capacity tiers

Load level	Indicative electric appliances	Capacity tier typically needed to power the load
Very low load (3–49 W)	Task lighting, radio, lightbulb or incandescent lightbulb, fluorescent tube, compact fluorescent lamp, light-emitting diodes (LEDs), smartphone (Internet phone) charger, regular mobile phone charger	TIER 1
Low load (50–199 W)	Black-and-white television, computer, fan, flat-screen color television, regular color television, DVD, printer, electronic tablet, satellite dish	TIER 2
Medium load (200–799 W)	Indoor air cooler, refrigerator, water pump, rice cooker, sewing machine, electric water cooler, freezer, electric hot water pot or kettle, blender, electric food processor	TIER 3
High load (800–1,999 W)	Washing machine, electric iron, microwave oven, electric toaster, dishwasher, electric hairdryer	TIER 4
Very high load (2,000 W or more)	Space heater, electric water heater, solar-based water heater, electric stove	TIER 5

Source: Bhatia and Angelou 2015.

A key issue that the MTF survey explores is the nature of the barriers that prevent a household from moving to a higher tier for access to electricity. This is the value added of the MTF survey. By capturing full-spectrum data, it empowers policy makers to pursue data-informed energy policies and to design interventions that remove barriers, so households can graduate to higher tiers. The value of access to electricity for households is defined by analyzing the MTF attributes based on responses to questions in the MTF survey, as follows:

- ***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 diodes (LEDs) and mobile phone chargers to several thousand watts for space heaters or air conditioners (see Table 1; Annex 1, Table A.1).
- ***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 (Between 6 pm and 10 pm) 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
- ***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.
- ***Affordability*** ("Can I afford to purchase the minimum amount of electricity?"): The affordability of the electricity service is determined by whether the cost of a standard consumption package of 365 kilowatt-hours a year is less or more than 5% of a household's annualized expenditure.
- ***Formality*** ("Is the service provided formally or by informal connections?"): If households use the electricity service from the grid, but do not pay anyone for the consumption, their connection could be defined as an informal connection.
- ***Health and Safety*** ("Is it safe to use my electricity service?"): The spectrum of electrical injuries is broad, ranging from minor burns to severe shocks and death. The Health and Safety attribute relates to high-risk, permanent injuries from the energy supply.

For each of these attributes, households are placed in a tier depending on the level of service as defined by the different thresholds. (See Annex 1 for thresholds in the multi-tier matrix for measuring access to electricity.) A household's aggregate tier or level of access is determined by the lowest tier value the household obtains among the attributes. At the national level, in the locality (urban or rural), and by the gender of the household head (man or woman household head), the distribution of the final aggregated tier and the individual attribute tier for all households as a distribution can be presented.

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

Despite the well-documented benefits of access to clean cookstoves, around three 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).[8] The consequences of inefficient

8 Household air pollution has been associated with a wide range of adverse health impacts, such as increasing risk of acute lower respiratory infections among children ages under 5 and chronic obstructive pulmonary disease and lung cancer (in relation to coal use) among adults ages more than 30. An association between household air pollution and adverse pregnancy outcomes (such as low birthweight), ischemic heart disease, interstitial lung disease, and nasopharyngeal and laryngeal cancers may also be tentatively drawn based on limited studies (Dherani et al. 2008; Rehfuess, Mehta, and Prüss-Üstün 2006; Smith, Mehta, and Maeusezahl-Feuz 2004).

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, Franco, Masera, Troncoso, and Rivera 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 attack (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 A, Table A.2).

- ***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.[9] 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 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.[10]
- ***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. 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. In this report, however, the fuel expenditure is only considered in determining the Affordability tier.
- ***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.

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9 In this report, ventilation is defined as the operation of a chimney, hood, or other exhaust system while a stove is in use or the availability of doors or windows that may be opened in the cooking area.

10 In cases where the cookstove also serves as a source of heating for the dwelling, the efficiency attribute should be ignored because heat-transfer efficiency becomes irrelevant.

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 I.).

BOX 4 • TYPOLOGY OF COOKSTOVES IN MYANMAR

In consultation with development partners and government officials, cookstoves in Myanmar have been classified into the following four categories (Annex 3):

Three-stone stoves consist of a pot balanced on three stones over a three-stone stove. The pot sits on the flames and the fuel rests on the ground. In general, this stove uses firewood and has a low combustion temperature; its fire is exposed to cold wind causing the heat to be lost to the ambient air.

Traditional stoves typically use conventional material to insulate the fire, and the pot rests above the flames. It is also produced locally using available, low-cost materials and fuels, reflecting cultural practices.

Improved cookstoves (ICS) insulate the fire more effectively, and the fuel rests on a shelf so that it reaches higher temperatures. There are three types of improved cookstoves in Myanmar:

- The **rocket stove**, a wood-burning stove with a high internal combustion chamber, promoting the mixture of combustion gases and heated oxygen. The combustion chamber is insulated, and the fuel resides on a shelf to promote higher fuel temperatures.
- The **conventional improved cookstove** is a charcoal stove with an insulated combustion chamber. The pot resides above the charcoal.
- The **advanced insulation stove** is a charcoal stove in which the combustion chamber is insulated with advanced materials.

Clean fuel stoves use clean and efficient fuels, such as liquefied petroleum gas (LPG), electricity, or biogas.

USING THE MULTI-TIER FRAMEWORK TO DRIVE POLICY AND INVESTMENT

The MTF survey provides detailed household energy data for governments, development partners, the private sector, nongovernmental organizations, investors, and service providers. On the supply side, it captures data on all energy sources that households use, with details on each MTF attribute. On the demand side, it provides data on energy-related spending; energy use; user preferences; willingness to pay (WTP) for the grid, off-grid, and cooking solutions; and the satisfaction of customers with their primary energy source.

Insights derived from the MTF data enable governments to set country-specific access targets. The data can be used in setting targets for universal access based on the country's conditions, the resources available, and the target date for achieving universal access. They can also help governments balance improvements in energy access among existing users (raising electrified households to higher tiers) and providing new connections. They also help governments determine the minimum tier the new connections should target.

MTF data can inform the design of access interventions, in addition to prioritizing them so that they may have the maximum impact on tier access for a given budget. The data can be disaggregated by attribute and technology, providing insights into the deficiencies that restrict households in lower tiers and the key barriers, such as lack of generation capacity, high energy cost, or a poor transmission and distribution network. Access interventions can thus be targeted to maximize household access. MTF data provide guidance on the technologies that are most suited to satisfy the demand of nonelectrified households (for example, grid or off-grid). And MTF data on demand, such as energy spending, WTP, energy use, and appliances, inform the design and targeting of government programs, projects, and investments for energy access.

The MTF surveys provide three types of disaggregation: by urban or rural location, by quintile, and by the gender of the household head. In addition, MTF survey also collects various socio-economic indicators such as expenditure and education for various analysis including the gender-disaggregated analysis.. Indicators such as primary energy source, tier of access, energy-related spending, WTP, and user preferences are disaggregated by male-headed and female-headed households. Such disaggregated analysis could add value to energy access planning, implementation, and financing. The MTF survey provides additional gender-related information, including on gender roles in determining energy-related spending and gender-differentiated impacts on health and time use.

MULTI-TIER FRAMEWORK SURVEY IMPLEMENTATION IN MYANMAR

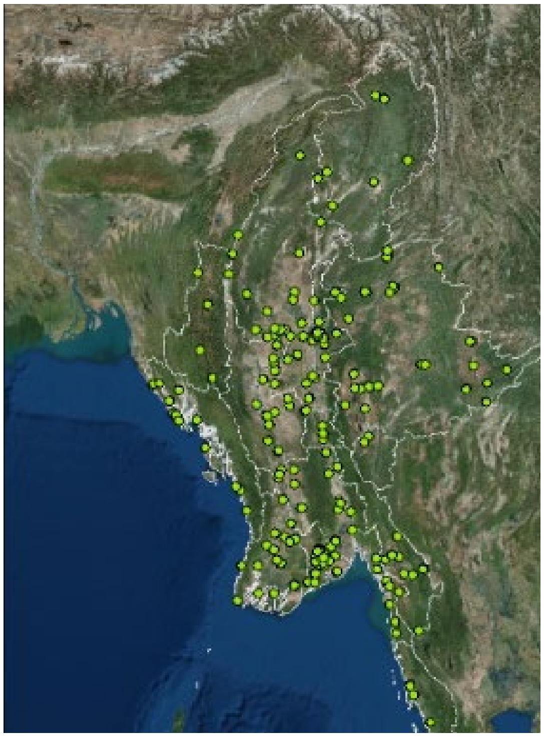
MTF data collection in Myanmar started in the first week of May and ended in the second week of July 2017. The household survey sample selection was based on a two-stage stratification aimed at achieving a nationally representative sample. The Central Statistical Organization and the Department of Population provided advice on sampling strategy using Myanmar's 2014 census database. The Department of Population aggregated the census data into enumeration areas and provided maps of the enumeration areas for the team in the field. A total of 3,446 households were surveyed following the stratification criteria: a 50:50 ratio of electrified and nonelectrified households for the tier analysis and an equal allocation between urban and rural areas (Table 2;Figure 1). The results of the MTF survey data collection and analysis were presented to the Ministry of Energy and Electricity, the Department of Rural Development, and development partners on July 31, 2018.

TABLE 2 • Distribution of enumeration areas and sampled households.

State/region	Urban				Rural				Total	
	Electrified		Nonelectrified		Electrified		Nonelectrified			
	EAs	HHs	EAs	HHs	EAs	HHs	EAs	HHs	EAs	HHs
Union	*69*	*1035*	*46*	*690*	*75*	*1125*	*40*	*600*	*230*	*3450*
Kachin State	2	30	3	45	1	15	1	15	7	105
Kayah State					2	30			2	30
Kayin State			8	120	2	30	1	15	11	165
Chin State	1	15	1	15			1	15	3	45
Sagaing Region	3	45	4	60	10	150	4	60	21	315
Tanintharyi Region			12	180			1	15	13	195
Bago Region	6	90			10	150	4	60	20	300
Magwe Region	4	60			6	90	4	60	14	210
Mandalay Region	10	150			13	195	4	60	27	405
Mon State	2	30	2	30	4	60	2	30	10	150
Rakhine State	3	45	5	75	2	30	4	60	14	210
Yangon Region	26	390			12	180	2	30	40	600
Shan State	6	90	9	135	7	105	4	60	26	390
Ayeyarwady Region	4	60	2	30	3	45	7	105	16	240
Nay Pyi Taw	2	30			3	45	1	15	6	90

Note: EA = enumeration area. HH = household

FIGURE 1 • Sample distribution



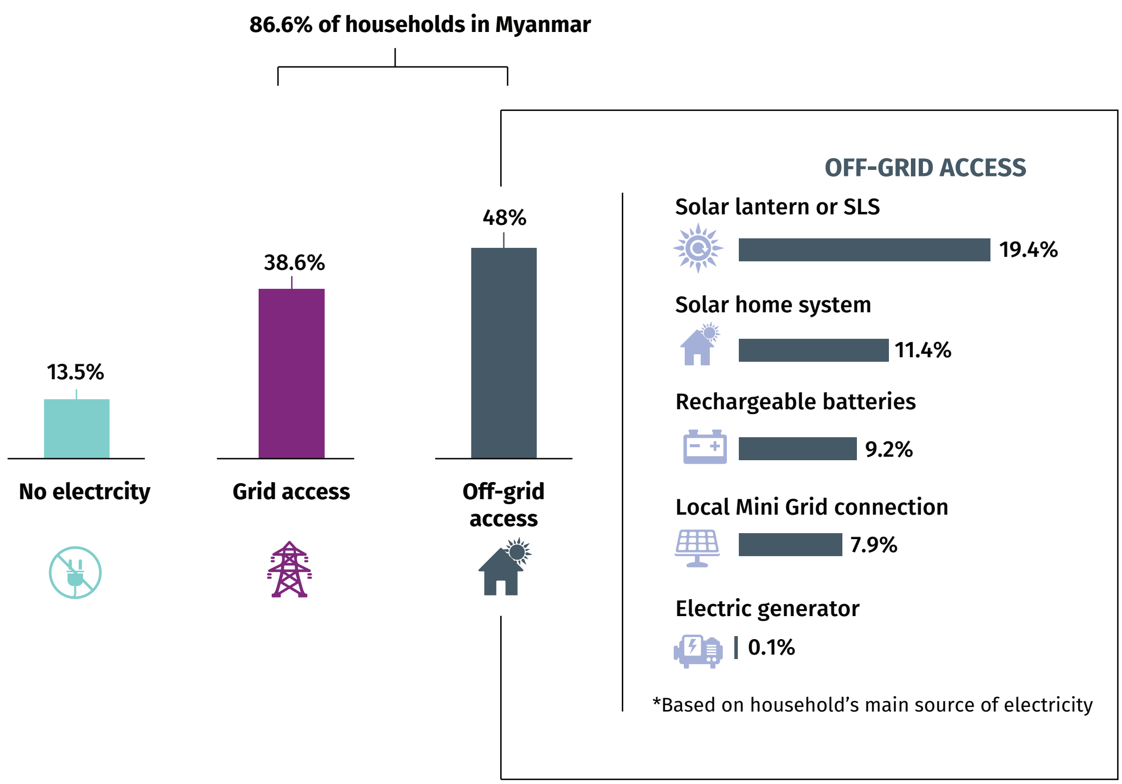
ACCESS TO ELECTRICITY

ASSESSING ACCESS TO ELECTRICITY

TECHNOLOGIES

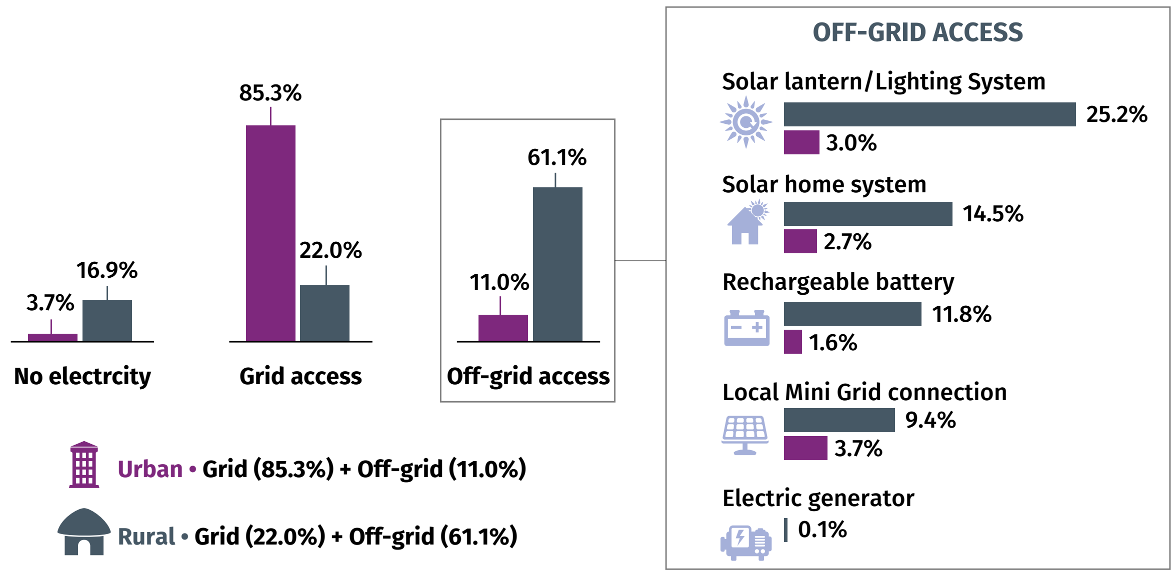
In Myanmar, 86.6% of households have access to at least one source of electricity: 38.6% have access through the national grid, while 48% use off-grid solutions. Off-grid solutions include 11.4% who rely on a solar home system (SHS) (Figure 2). A solar lantern or solar lighting system (SLS) that provides lighting and phone charging are used by 19.4% of the households; 9.2% of households use rechargeable batteries. A substantial number of households also use a mini-grid, that is, a communal or isolated grid system (7.9%).

FIGURE 2 • **Access to electricity by technology, nationwide**



Urban and rural households use off-grid solutions. However, off-grid solutions are more common among rural households (Figure 3). Discrepancies in electricity access among urban and rural households are wide. Among rural households, 61.1% use off-grid solutions as their primary source of electricity, of which 39.7% either use an SHS or a solar lantern or SLS; 11.8% use rechargeable batteries as their primary source of electricity. Discrepancies are also wide across states and regions (Box 5).

FIGURE 3 • **Access to electricity by technology, urban/rural**

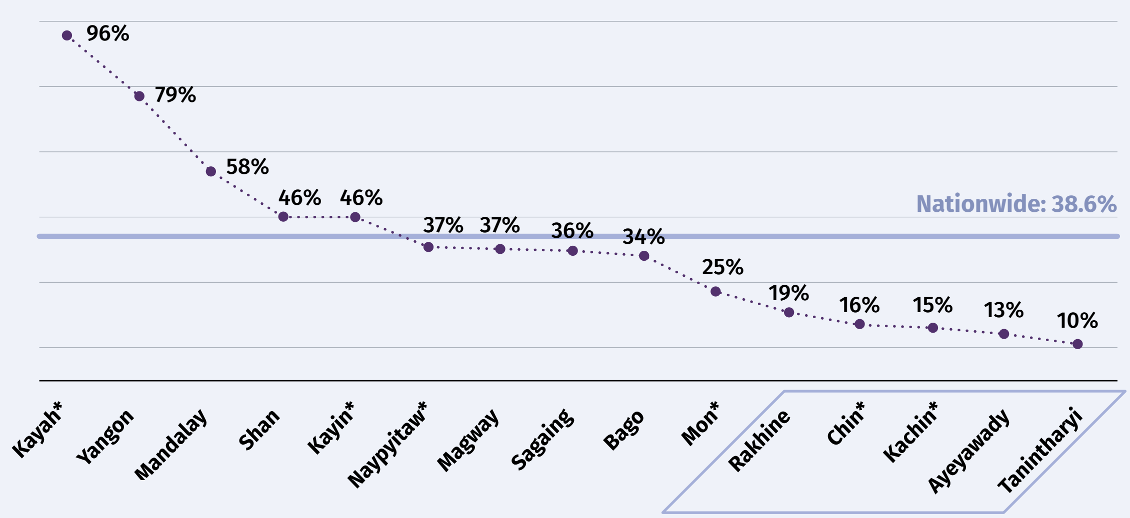


*Based on household's main source of electricity

BOX 5 • GRID ELECTRIFICATION RATE, BY STATE OR REGION

Leading the country in electrification are Kayah State (96%), Yangon Region (79%) and Mandalay Region (58%). The grid electrification rates in Rakhine, Chin, Kachin, Ayeyarwady, and Tanintharyi are significantly lower than the national average rate of 38.6%.

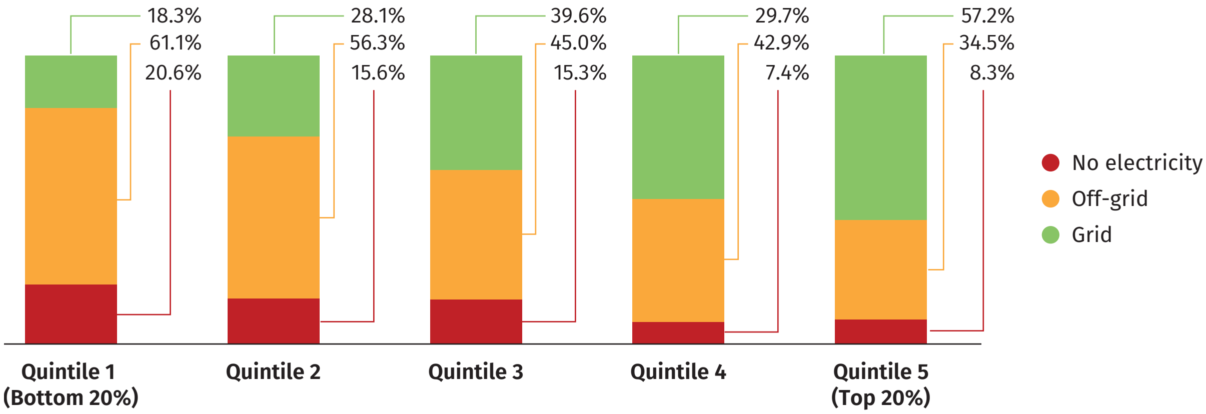
FIGURE B5.1 •**Grid Electrification Rate, by State or Region**



** States and regions with asterisk mark indicate that sample size is too small for the values to be representative of the population and that the values have large standard errors.*

Among the highest expenditure quintile group (57.2%), the national grid is the most widely used source of electricity, while off-grid energy solutions are more widely used by lower expenditure quintile groups; 18.3% of the lowest spending quintile are connected to the grid (Figure 4). Lower-income households benefit more from off-grid solutions (mainly SHSs and rechargeable batteries): off-grid energy solutions are more widely used among the bottom 40%.

FIGURE 4 • **Access to electricity by technology by expenditure quintile**



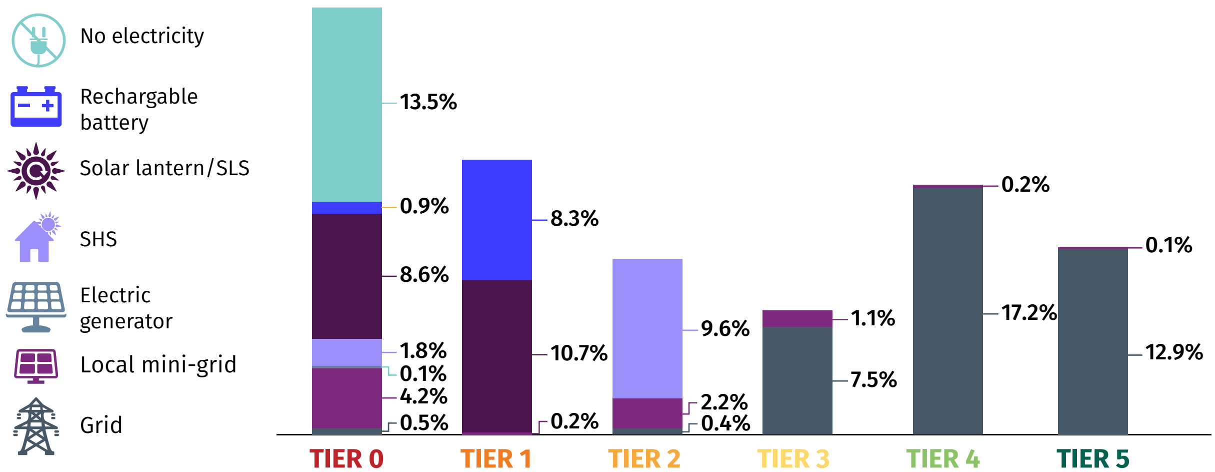
MTF TIERS

For electricity access, 70.3% of households fall into Tier 1 or above: 19.2% of households are in Tier 1, followed by Tier 4 (17.3%) (Figure 5554). Virtually all grid-connected households are classified as Tier 3 or above. Among households not connected to the grid, mini-grids and off-grid solar devices become critical methods of gaining access to an electricity source. Households classified in Tiers 1 or 2 gain electricity access via mini-grid, solar lantern or SLS, or rechargeable batteries. Most households that use an off-grid solar device are in tier 1, but some are also Tier 0.

In electricity access, 29.7% of households fall into Tier 0: 13.5% of households have no electricity.[11] Tier 0 categorization does not necessarily mean that the household does not have access to an electricity source. Of the 29.7% Tier 0 households, 16.2% use energy solutions that do not provide at least Tier 1 electricity service (for example, less than four hours of electricity supply per day); 10.4% use an off-grid solar device, 4.2% depend on a minigrid, and 0.9% rely on rechargeable batteries as an electricity source and still have Tier 0 access.

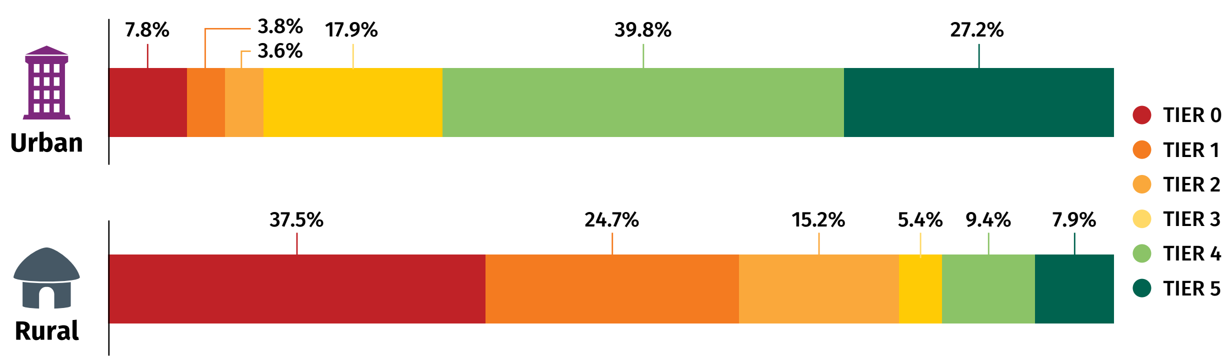
11 Households using dry-cell battery is defined as having no electricity according to the MTF

FIGURE 5 • **MTF tier distribution, by technology, nationwide.**



Electricity access is mostly a rural challenge: 37.5% of rural households are in Tier 0, while 7.8% of urban counterparts fall into this category. In similar fashion, 7.4% of urban households fall into Tiers 1 or 2, while more than a third (39.9%) of rural households are in these categories (Figure 6). The disparity between urban and rural households is reflected in the aggregate tier average: Tier 3.6 among urban households, compared with Tier 1.6 among rural households.

FIGURE 6 • **MTF tier distribution, urban/rural**

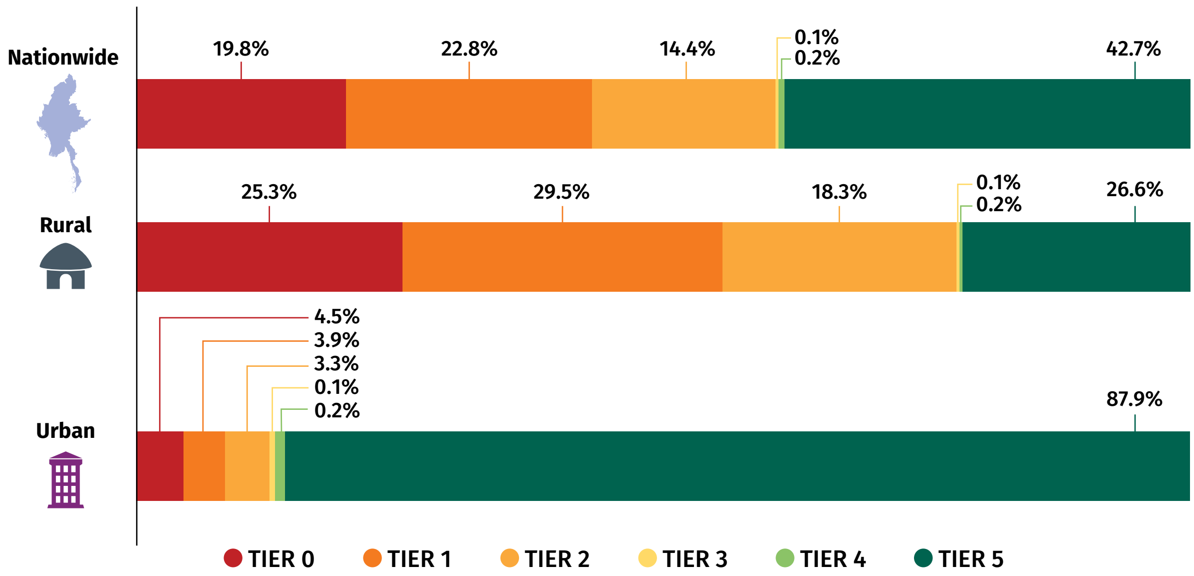


MTF ATTRIBUTES

Capacity

The Capacity attribute represents the ability to provide a certain amount of electricity to power various appliances, ranging from a few watts for 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 kilowatts). 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. (Figure 7).

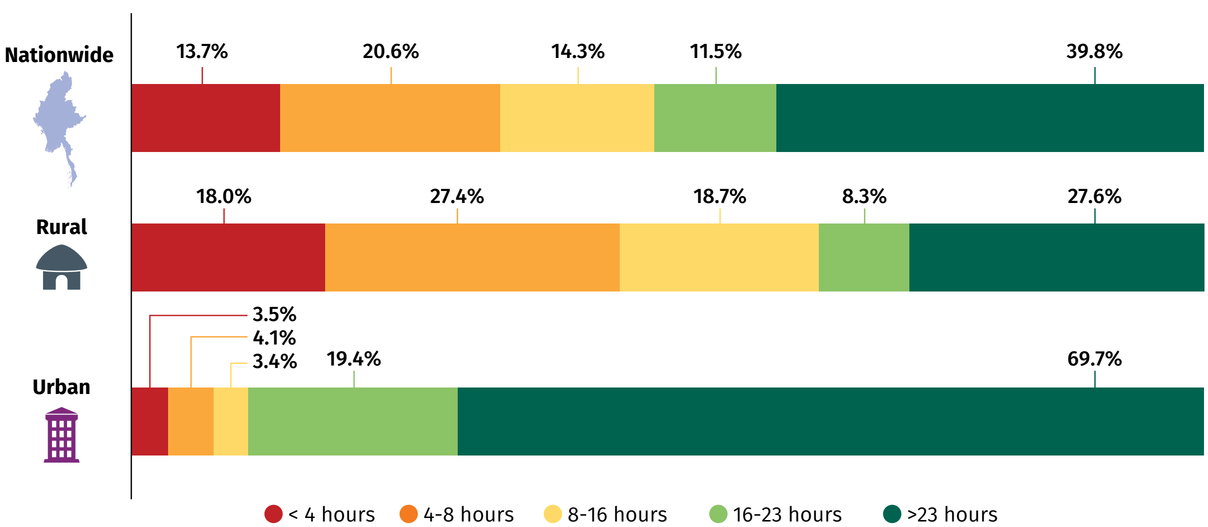
FIGURE 7 • Distribution of households based on Capacity (nationwide, urban/rural)



Availability

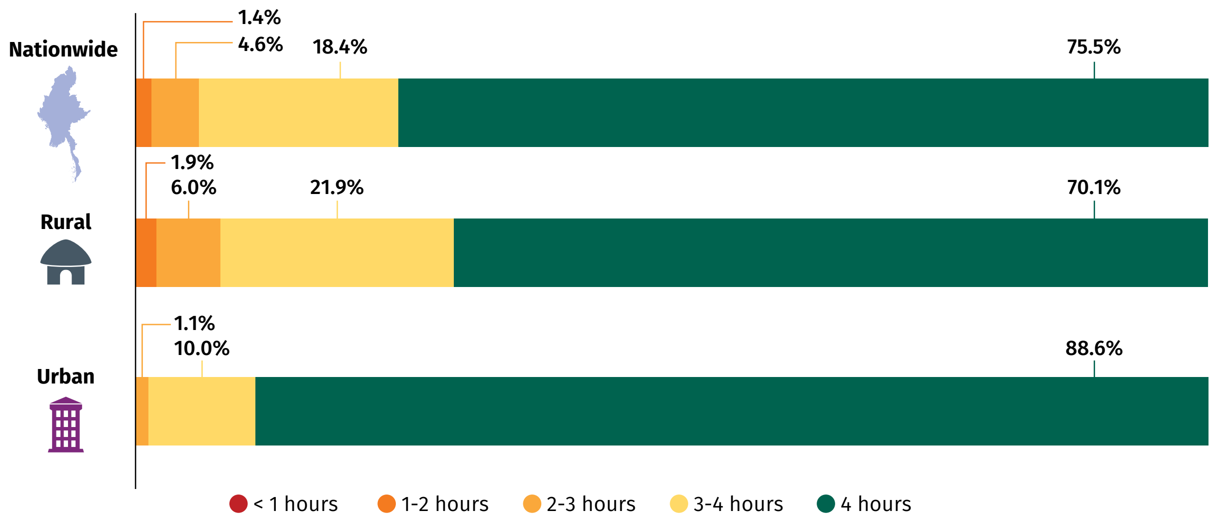
The Availability attribute consists of two components: daily (24 hours) and evening availability (4 hours between 6 and 10 pm). In Myanmar, 39.8% of households have electricity for at least 23 hours a day, seven days a week, while 13.7% of households receive less than 4 hours of service per day (Figure 8). Most households that have less than 4 hours of electricity per day primarily use either an off-grid solar solution or a mini-grid source. In rural areas, limited availability is more acute: 69.7% of urban households have at least 23 hours of electricity access a day, compared with the 27.6% of rural households that have access for the same duration.

FIGURE 8 • Distribution of households based on Daytime Availability (over a 24-hour day) (nationwide, urban/rural)



Households have more electricity supply during the evening (Figure 9): 75.5% of households have four hours of electricity supply during the evening. The evening duration is long even among rural households, 70.1% of which have the full four hours. Most households with an off-grid solution use electricity mainly for lighting during the evening. The evening availability tier is thus generally higher than the daily Availability tier.

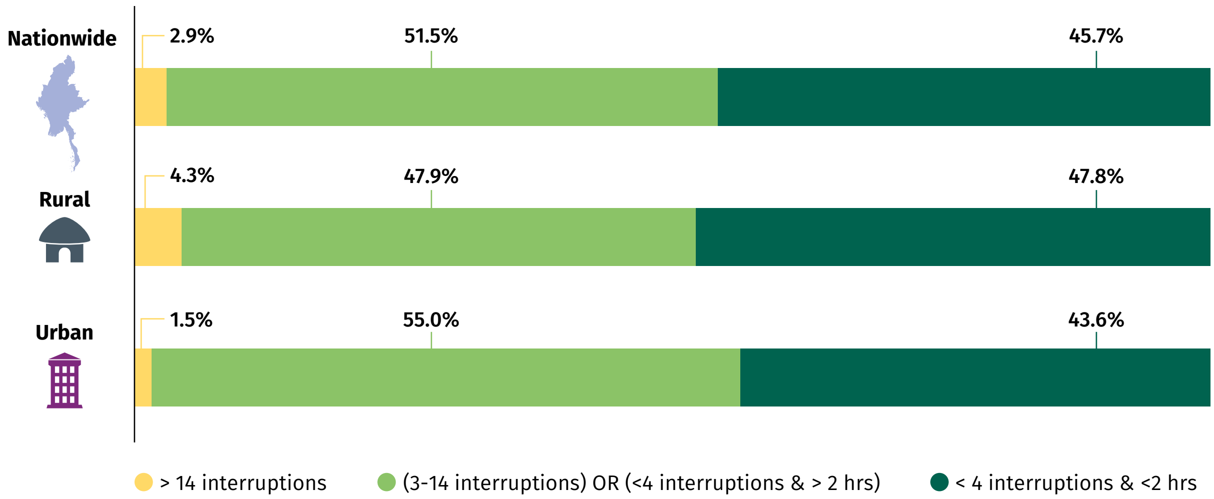
FIGURE 9 • **Distribution of households based on Evening Availability (over a 4-hour from 6 pm to 10 pm) (nationwide, urban/rural)**



Reliability

The Reliability attribute captures the frequency and duration of unscheduled outages, and it only applies to grid-connected households. In Myanmar, over half of the grid-connected households (54.5%) face frequent, unpredictable power outages (Figure 10). Most of them suffer from 4 to 14 interruptions per week lasting over 2 hours in total. Reliability tends to be slightly better in rural areas.

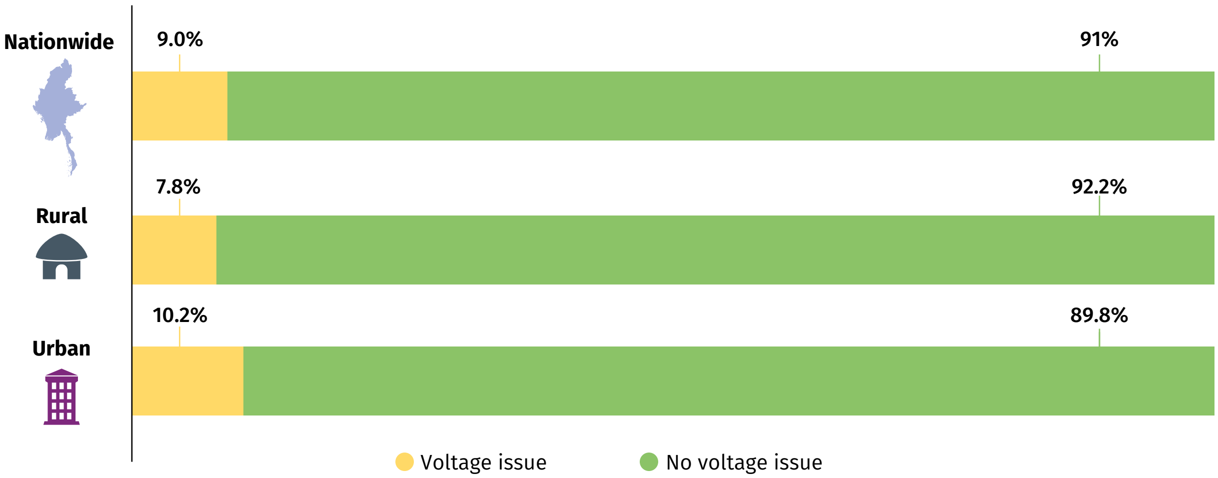
FIGURE 10 • **Distribution of households based on Reliability (nationwide, urban/rural)**



Quality

The Quality attribute applies only to households on either the national grid or mini-grids. Among households connected either to the national grid or to mini-grids, 9% face voltage issues, such as low-power or fluctuating service, resulting in appliance damage. An overloaded electricity system that sometimes relies on long-distance, low-tension cables to connect widely scattered households to a singular grid can create erratic voltage. Surges can harm electrical appliances because these generally require a certain range of voltage to operate properly. Low-voltage or fluctuating supply tend to damage electrical appliances, sometimes causing shorted wires and electrical fires.

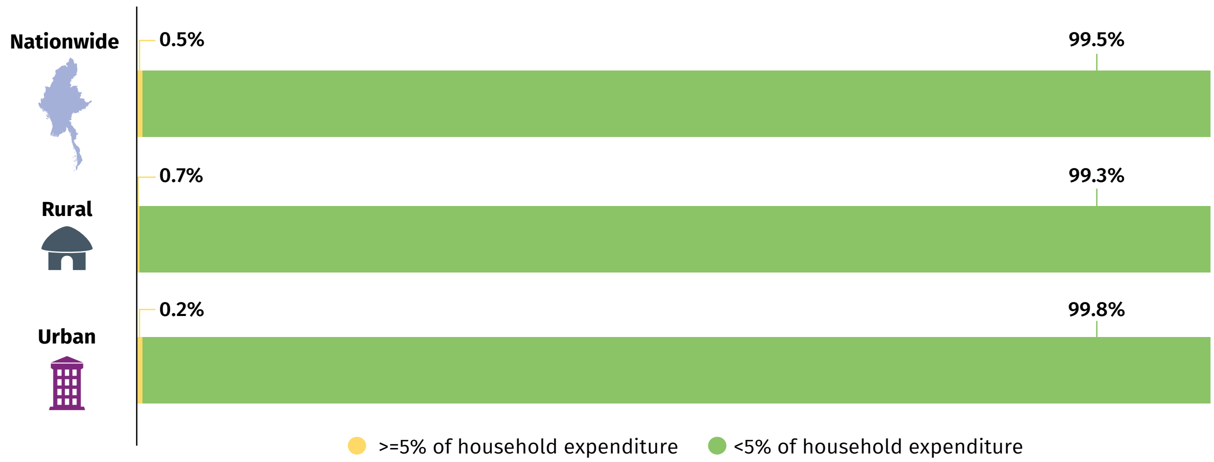
FIGURE 11 • **Distribution of households based on Quality (nationwide, urban/rural)**



Affordability

The Affordability attribute measures whether the current electricity tariff is affordable for households. If a household spends more than 5% of the household expenditure on electricity to consume 1 kilowatt-hour a day and 30 kilowatt-hours a month, the electricity is it is assumed not to be affordable. Less than 1% of urban and rural households in Myanmar fall into the Tier 2 category for Affordability. Thus, the current electricity price is affordable for most of the population, who pay less than 5% of their household expenditure for gaining basic electricity service (meaning,at least 1 kilowatt-hour a day) (Figure 12).

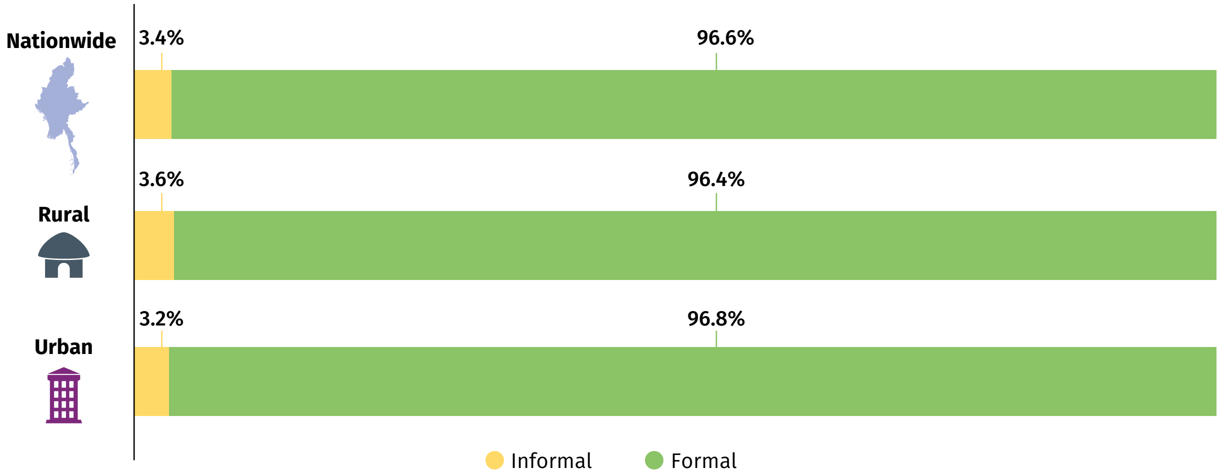
FIGURE 12 • **Distribution of households based on Affordability (nationwide, urban/rural)**



Formality

The Formality attribute assesses whether a household's connection to the grid has been provided or sanctioned by a governing authority. In Myanmar, 3.4% of grid-connected households have an informal grid connection; because an informal electricity supply is unlikely to be regulated, this may pose a safety risk (Figure 13). Reporting on Formality is a challenge because household respondents may be sensitive to disclosing information on the nature of their grid connection in a documented survey. As a result, the MTF survey infers the Formality of connections through indirect questions that respondents may be more willing to answer, such as a question about the agent to whom the household pays the electricity bill.

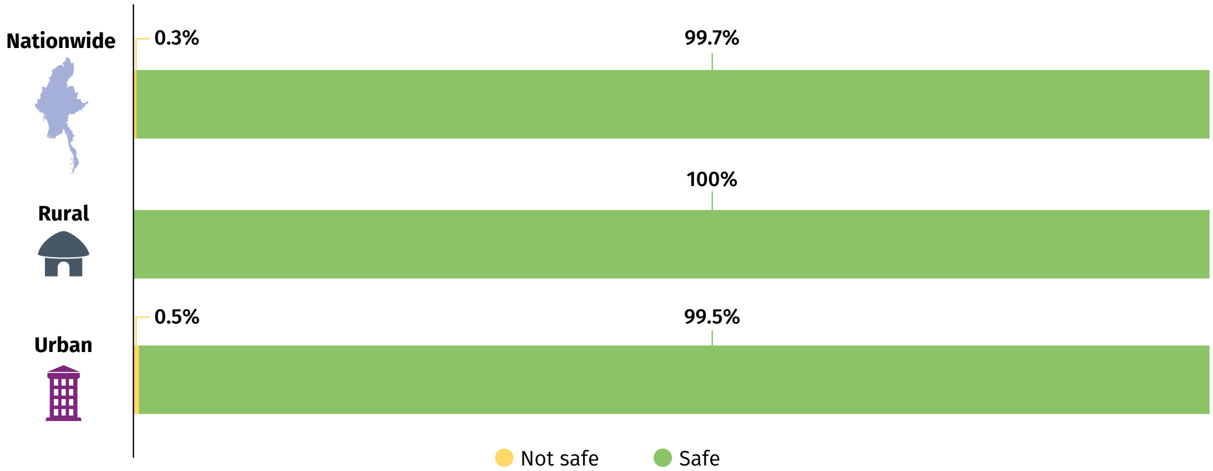
FIGURE 13 • **Distribution of households based on Formality (nationwide, urban/rural)**



Health and Safety

The Health and Safety attribute concerns injuries to any household members because of the use of an electricity service from the grid at the time of the survey or in the 12 months previous to the survey. Electricity supply from the national grid is generally safe, and only 0.3% of households reported permanent limb damage or death because of electrocution (Figure 14). However, ensuring that all household members are aware of basic safety measures is important; moreover, to prevent accidents, households must be encouraged to install all wiring according to national standards.

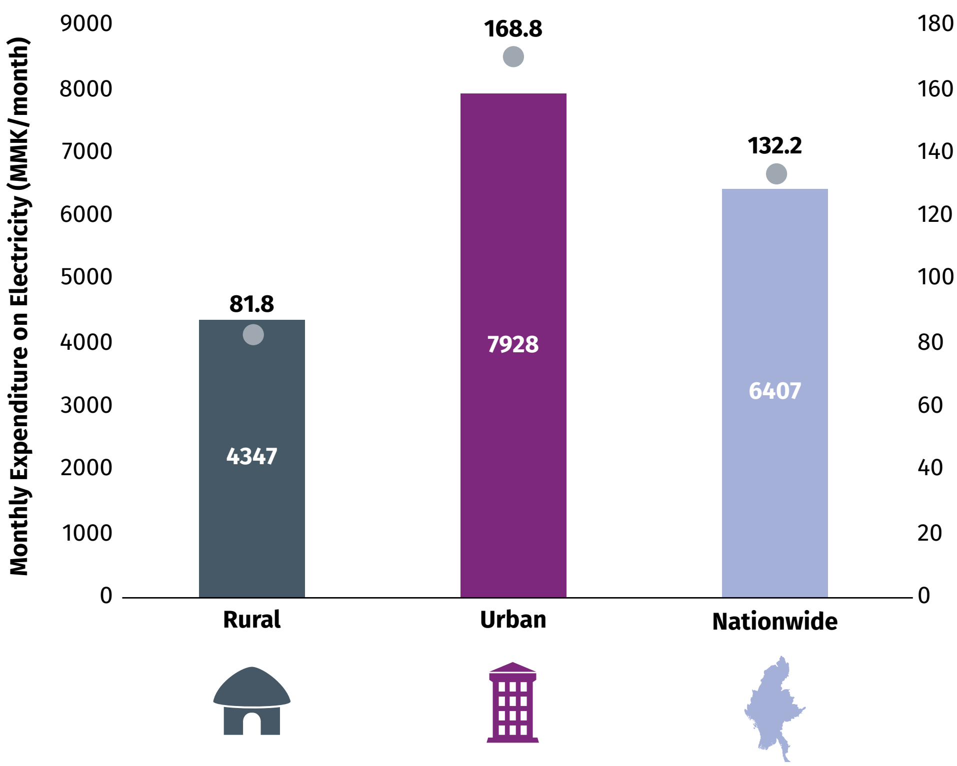
FIGURE 14 • **Distribution of households based on Health and Safety (nationwide, urban/rural)**



USE

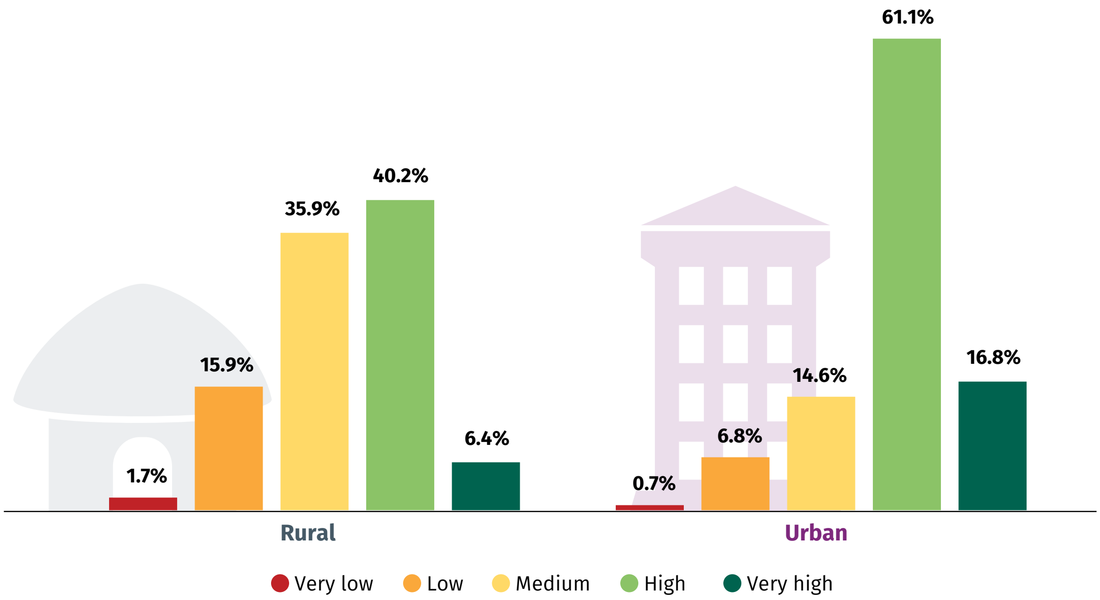
Grid-connected households consume an average 132 kilowatt-hours monthly. Urban households consume almost double the consumption of rural households, respectively, 169 kilowatt-hours a month and 82 kilowatt-hours a month. Spending on electricity accounts for 2.6% of average monthly household expenditure. The shares are slightly larger (2.9%) among urban households (K 7,928, or US$5.20 a month) and slightly lower (2.2%) among rural households (K 4,347, or US$2.90 a month). Rural households with access to the national grid have been electrified for an average 5.8 years, compared with 11.2 years among corresponding urban households, which means that national grid connections are a relatively new phenomenon in rural areas.

FIGURE 15 • **Monthly household expenditure and consumption of electricity**



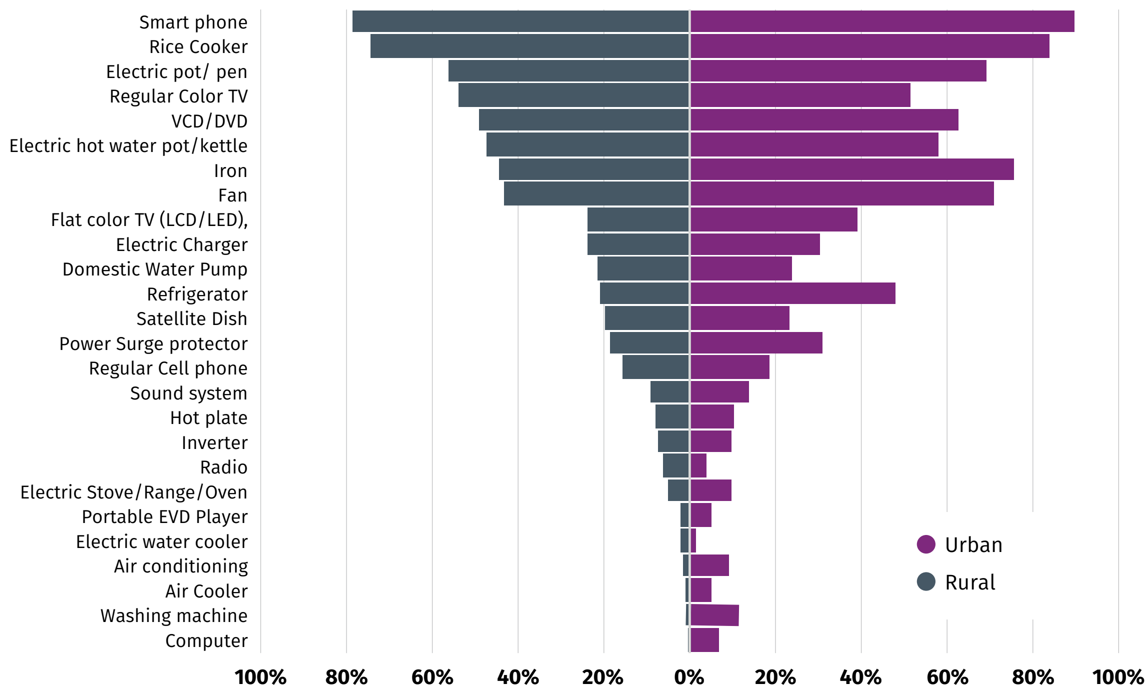
Urban households tend to own more higher-load appliances relative to rural households. While only 7.5% of urban households rely on very low load or low load appliances, such as lighting or mobile phone chargers, 17.6% of rural households use such appliances exclusively. An overwhelming share of urban grid-connected households (77.9%) own high load or very high load appliances (such as electric stoves or air conditioners). In contrast, less than half the grid-connected households in rural areas use high load or very high load appliances (Figure 16).

FIGURE 16 • **Household ownership of appliances by load level**



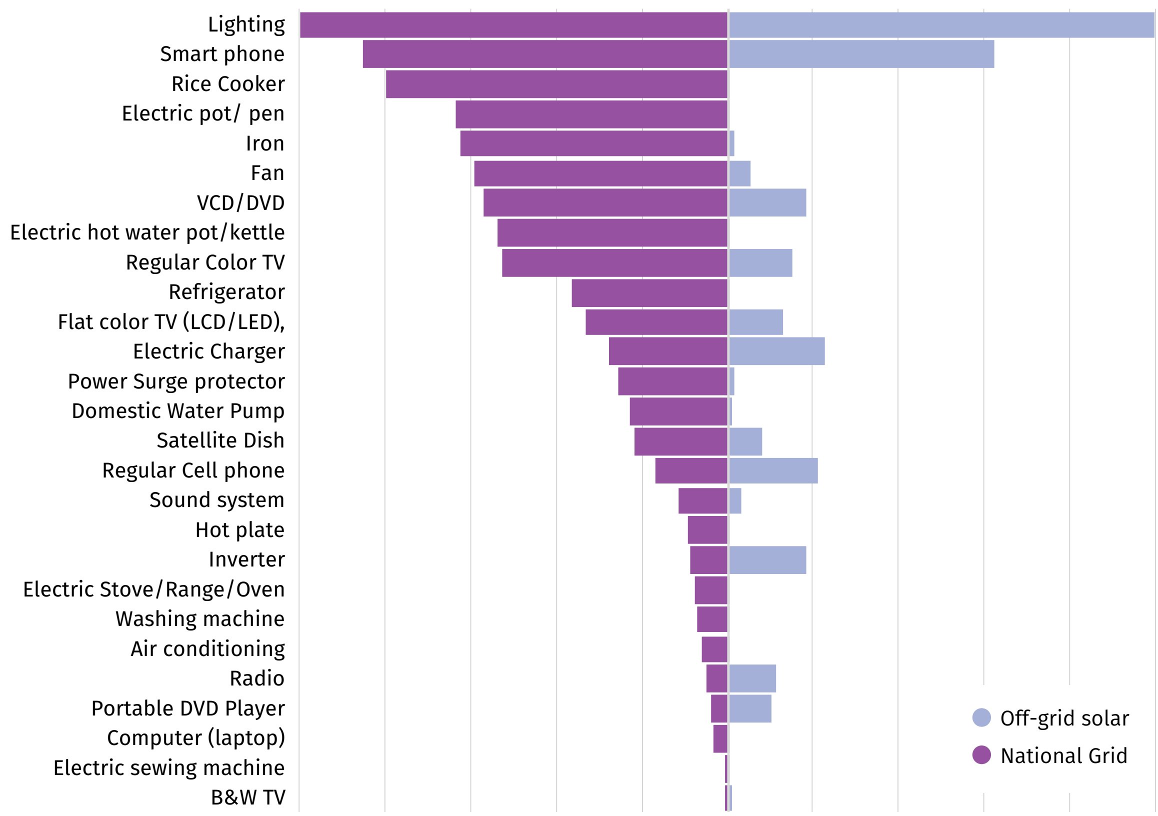
In rural areas, high and very high load appliances, such as washing machines (1.0%), air conditioners (1.5%), and electric stoves (4.9%), are relatively rare among grid-connected households (Figure 17). Among grid-connected urban households, 11.5%, 9.1%, and 9.4% use these appliances, respectively. This result may be attributed to the high price of electricity or the high cost of appliances for many households. Because many households have been electrified for less than five years, consumption and appliance ownership may yet expand.

FIGURE 17 • **Grid-connected households' ownership of appliances, urban/rural**



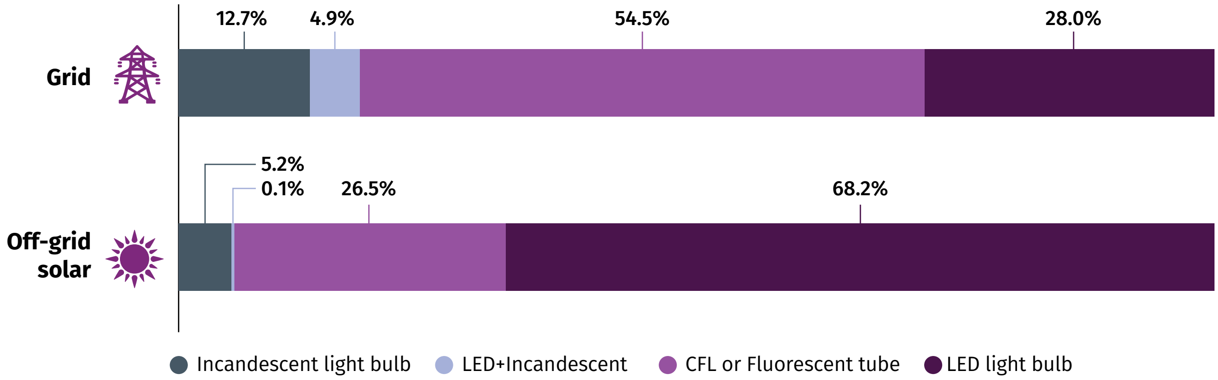
Households that possess off-grid solar devices use them mostly for lighting, charging smartphones (62%) or regular phones (21%), playing DVDs (30%), watching television (30%), or listening to the radio (12%).

FIGURE 18 • **Households ownership of appliances by grid/off-grid solar households**



In Myanmar, the use of LED light bulbs - the most efficient lighting technology - is 68% in off-grid households, and 28% in grid connected households. Compact fluorescent lights (CFL), also an efficient lighting technology - although less efficient than LED - are used by over half of grid-connected households and also in over a quarter of off-grid households. Incandescent lights, an old and inefficient technology, are still used by almost a fifth of the gird connected households and in about 5% of off-grid households. (Figure 19)

FIGURE 19 • **Types of lightbulbs used by grid and off-grid solar households**

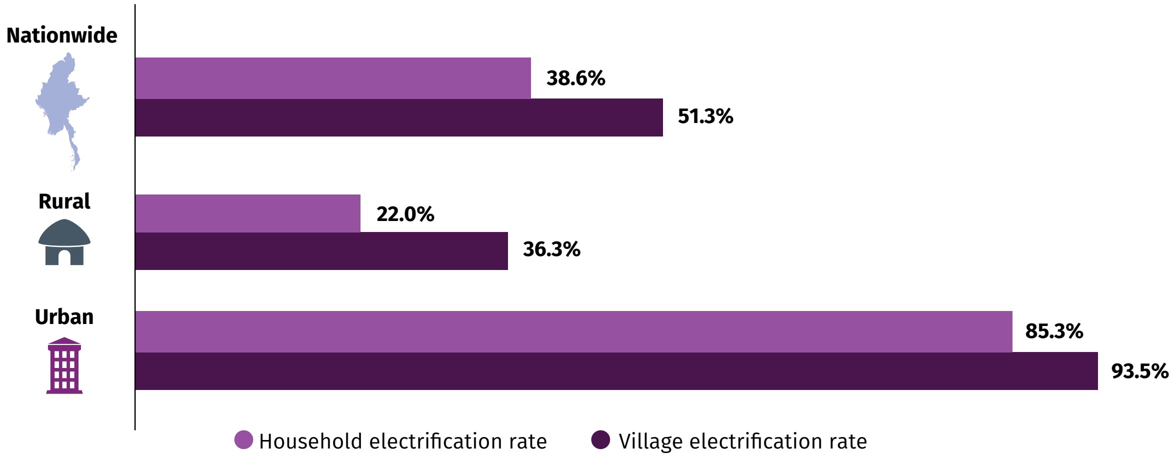


IMPROVING ACCESS TO ELECTRICITY

PROVIDING ELECTRICITY ACCESS TO HOUSEHOLDS WITHOUT A SOURCE OF ELECTRICITY

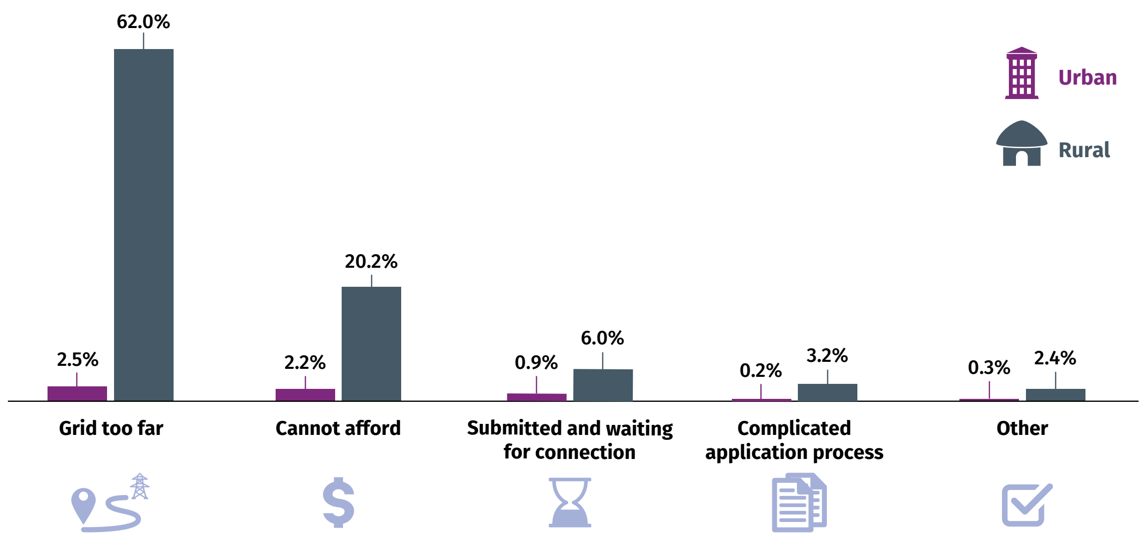
About 38.6% of households in Myanmar are connected to the grid. However, 51.3% of households are located in villages where the grid is available (i.e. in villages where at least one household is connected to the grid) (Figure 20). Thus, densification projects may enable about 12% of household nationwide to get access to the existing grid.

FIGURE 20 • **Comparison between the village electrification rate and the household electrification rate**



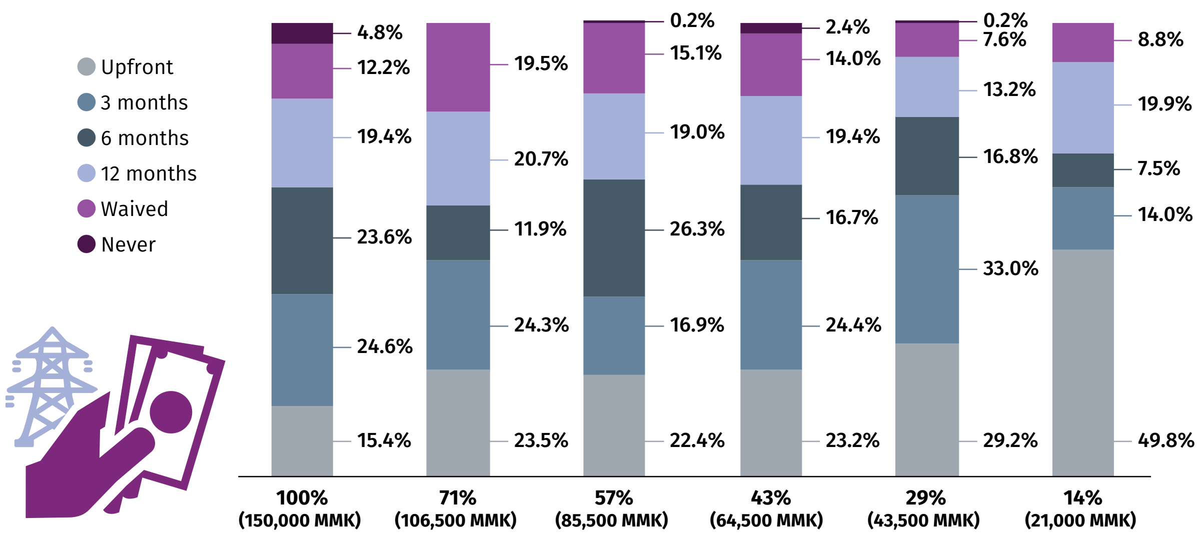
The barriers preventing households from gaining a connection are as follows: the distance to the grid (64.5%), the high up-front cost of obtaining grid access (22.4%) and delays or difficulties in the administrative process (10.3%) (Figure 21).

FIGURE 21 • **Barriers to gaining access to grid electricity**



Offering payment flexibility, such as payment on installment, can effectively address the burden of the high up-front cost of connection. Unconnected households show a higher willingness to pay for the connection fee if the cost is spread out over time (Figure 22). Offering payment flexibility to potential users could increase the uptake of the national grid. Also, WTP of the up-front connection fee rises double when the amount to be paid drops to 30% of the full cost. Along with offering payment flexibility, another strategy would be to increase the access to financing among households in grid-electrified locations through microfinance institutions.

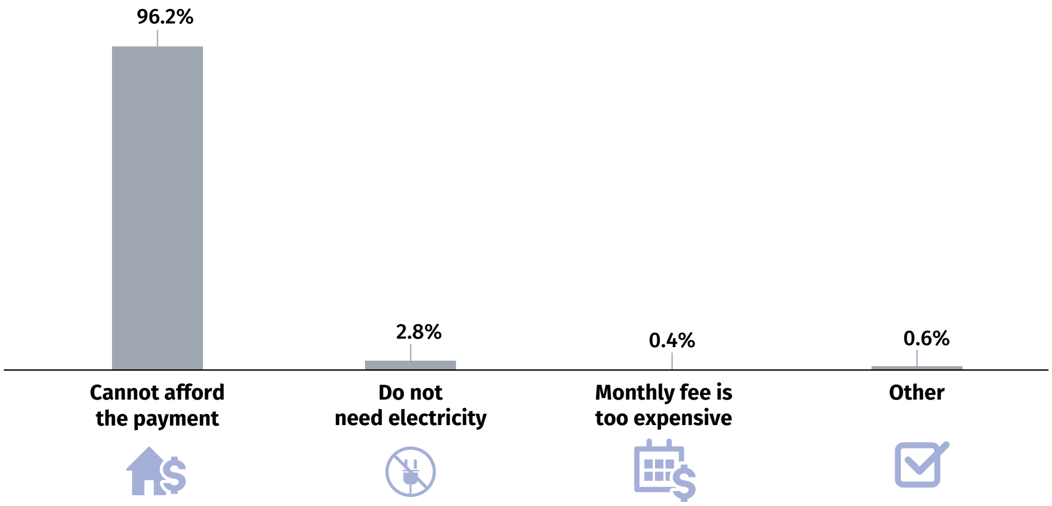
FIGURE 22 • **WTP for the grid connection fee**



The large majority of unconnected households that are not willing to pay for a grid connection reported that they cannot afford the cost of connection (including connection fee, internal wiring, etc.) (Figure 23).

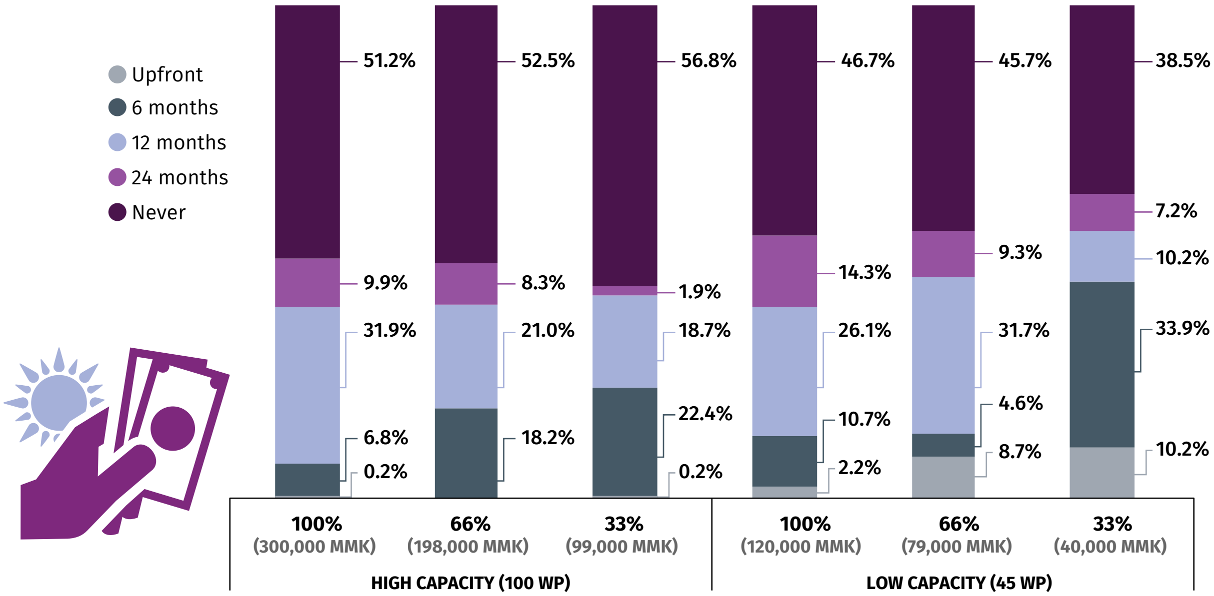
The lengthy and complex administrative process is also a barrier among unconnected households. More efficient administrative processes for applying for and obtaining the grid connection could help an additional 10.3% of nonelectrified households gain access to the grid.

FIGURE 23 • **Reasons for not accepting any offer to pay for a grid connection**



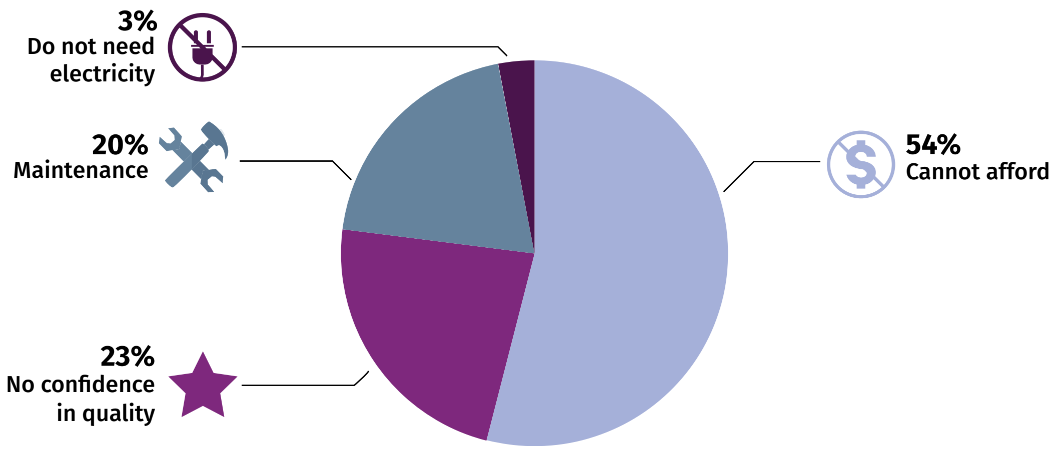
Over half of the households without grid electricity in Myanmar are not willing to pay for a high capacity solar home system (100 Wp), under any flexible plan, for a price ranging from 300,000 MMK (220 USD) to 99,000 MMK (73 USD) (Figure 24). Most households are willing to pay for a low capacity solar home system (45 Wp) over a period of time (6, 12 or 24 months). Their willingness to pay increases slightly as the price of the system decreases.

FIGURE 24 • **WTP for a SHS**



Over half of the households are not willing to pay for a solar home system because they cannot afford the cost, while 23% of them have low confidence in the quality of the system. An additional 20% is concerned about the maintenance required (Figure 25).

FIGURE 25 • **Reasons for not WTP for a SHS**

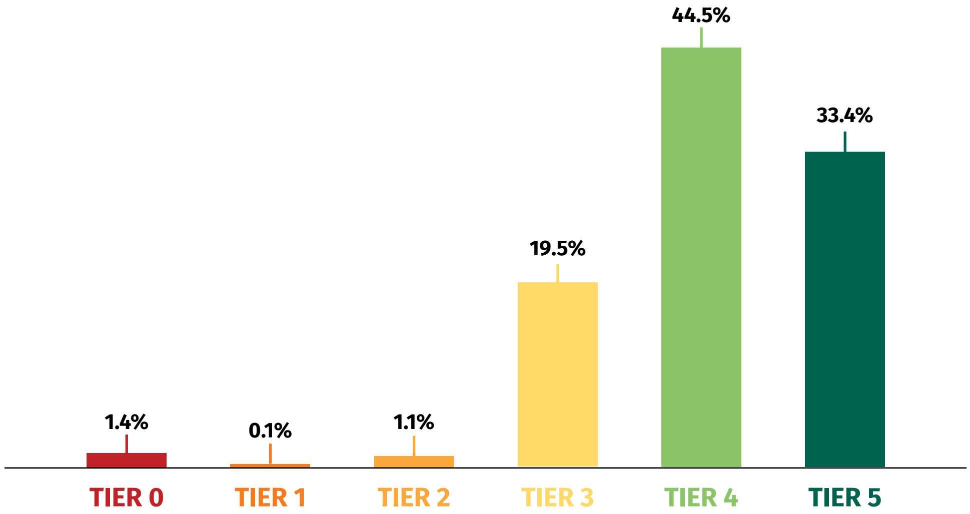


To cope with the high up-front cost of an SHS, the National Electrification Plan (NEP) provides subsidies to install 160,000 solar systems in households and other entities. With a subsidy, the second phase of the project requires a 30%–55% contribution from households, which roughly corresponds to the 66% price point in the WTP analysis. In addition to the subsidy, supplying adequate consumer financing would have a sizable positive impact on the off-grid solar penetration rate. Because several companies offering high-quality products are willing to market and support households with no electricity or poor-quality solar devices, microfinancing and leasing opportunities could increase the adoption of higher-quality solar systems. Consumer awareness programs could assist potential customers in choosing good-quality products and using them sustainably, thus addressing households' lack of confidence in the quality of the systems.

IMPROVING ACCESS TO ELECTRICITY AMONG GRID-CONNECTED HOUSEHOLDS

The national grid provides a decent quality of electricity service to customers (Figure 26). Nationwide, 98.9% of grid-connected households are in Tier 3 or above. The largest share of grid-connected households are in Tier 4 (44.5%). Electrification expansion in rural areas is a recent development relative to urban areas. The median household has been connected for about five years: the urban median is about seven years, and the rural median is around three years.

FIGURE 26 • MTF tier distribution of grid-connected households



Nationwide, Reliability and Quality are the main constraints keeping grid-connected households in Tiers 3 and 4 from reaching Tier 5. More than half the grid-connected households experience more than three outages a week, or more than two hours of interruptions, placing these households in Tiers 3 or 4 for Reliability (Figure 27 and Figure 28). Among grid-connected households, 9% have experienced appliance damage because of voltage fluctuations, placing these households in Tier 3.

FIGURE 27 • Distribution of grid-connected households based on Reliability

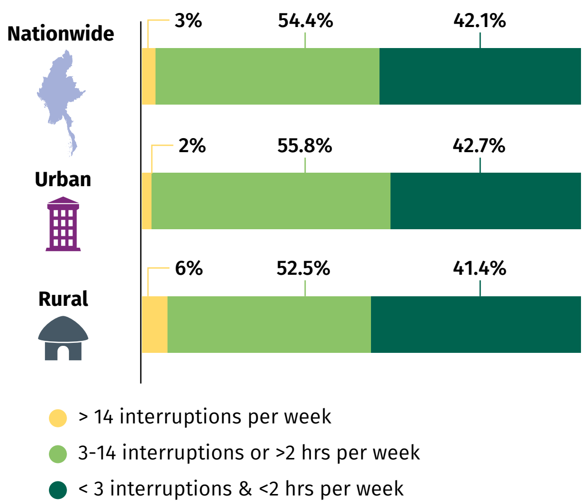
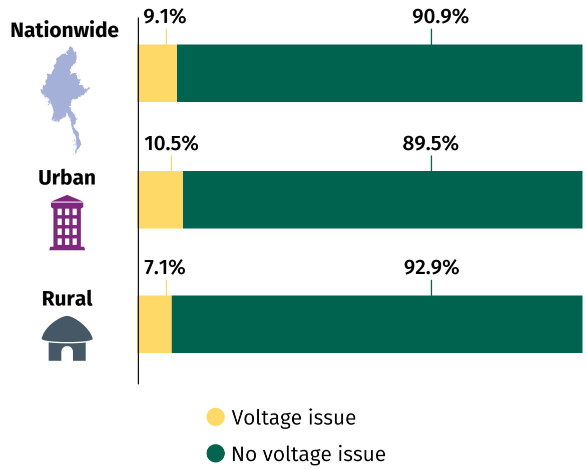
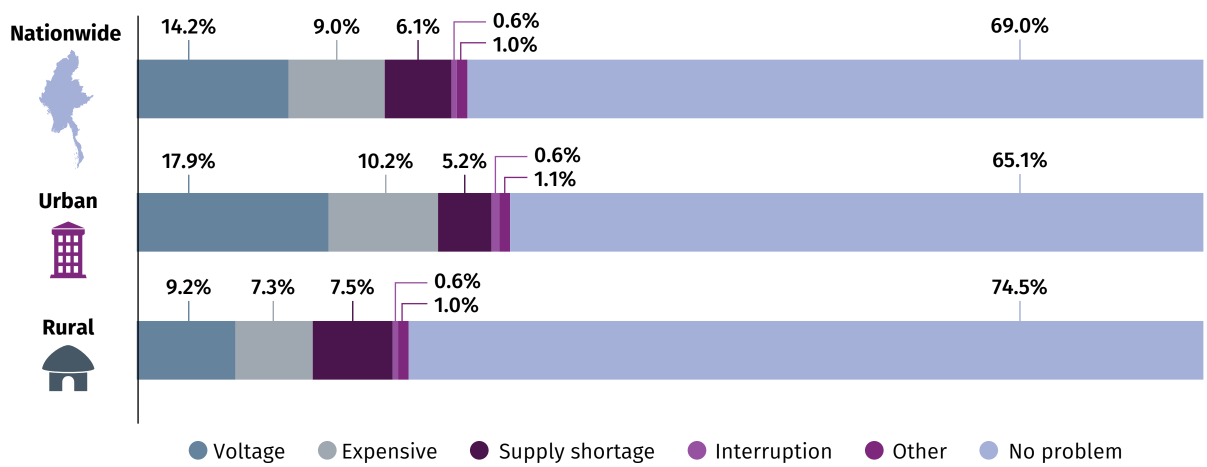


FIGURE 28 • Distribution of grid-connected households based on Quality



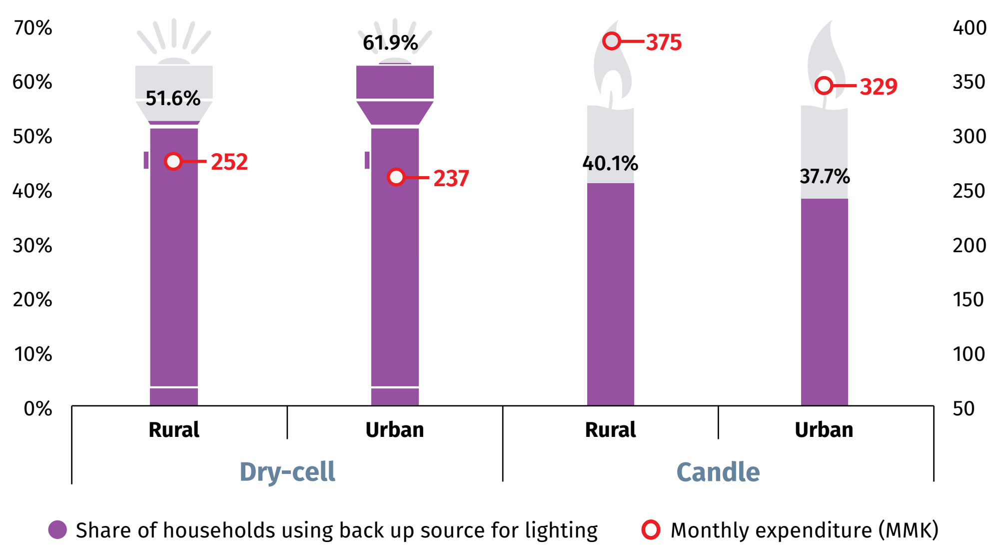
About 69% of grid-connected households reported that they have encountered no issue with their electricity supply (Figure 29). The remaining households reported voltage, cost and outages as the main issues regarding their electricity supply. These findings are based on consumer perceptions of key issues.

FIGURE 29 • **Main issues related to grid electricity supply (nationwide, urban/rural)**



To cope with power outages, 51.6% of rural households and 61.9% of urban households use flashlights as a backup source of lighting; 40.1% of rural households and 37.7% of urban households use candles (Figure 30). Roughly 17.0% of the grid-connected households do not have any backup source of lighting, and more urban households (18.6%) than rural households (14.7%) use a backup source.

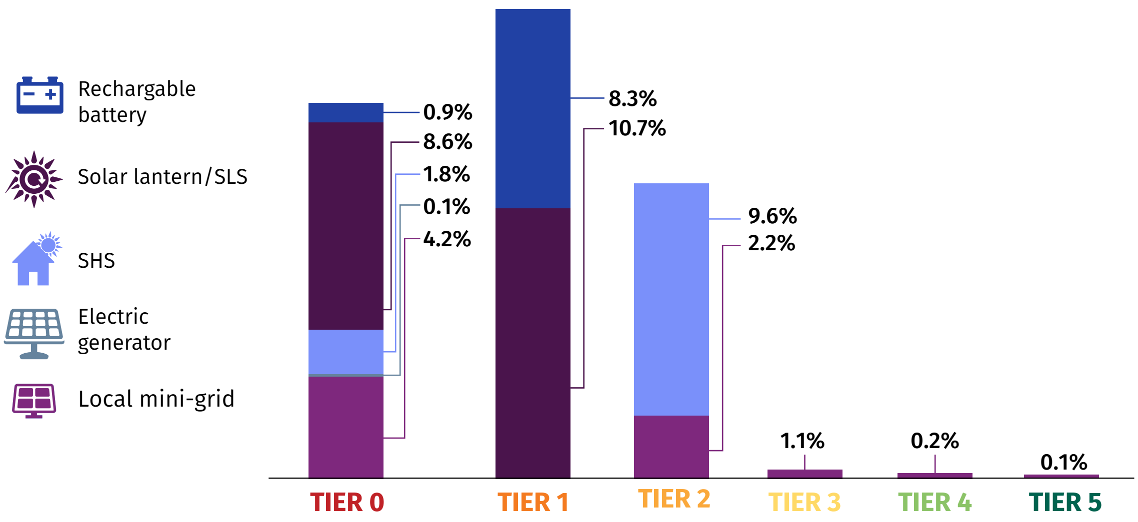
FIGURE 30 • **Grid-connected households using a backup source for lighting and the monthly expenditure on the backup source, urban/rural**



IMPROVING ELECTRICITY ACCESS AMONG HOUSEHOLDS THAT RELY ON OFF-GRID SOLUTIONS

In Myanmar, nearly half of all households (48%) rely on off-grid solutions. Wherever the national grid is unavailable, off-grid solar devices, mini-grids, which are mostly community-based isolated systems, and rechargeable batteries are helping fill the electrification gap. Virtually all households using off-grid solutions are in Tiers 0–2; fewer than 2% are in Tier 3 or above; More than half the households in Tier 0 that rely on off-grid energy solutions do not meet the minimum requirements for Tier 1 service. (Figure 31). Households depending on off-grid energy solutions are mainly constrained by the Capacity and Availability attributes.

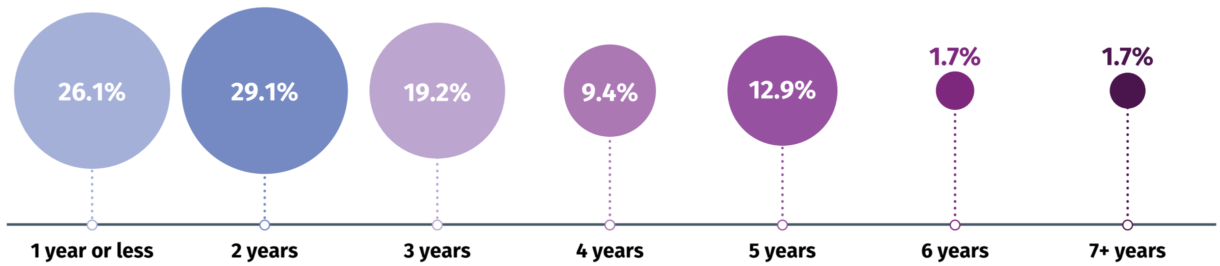
FIGURE 31 • **MTF tier distribution by off-grid technology**



Households using off-grid solar solutions

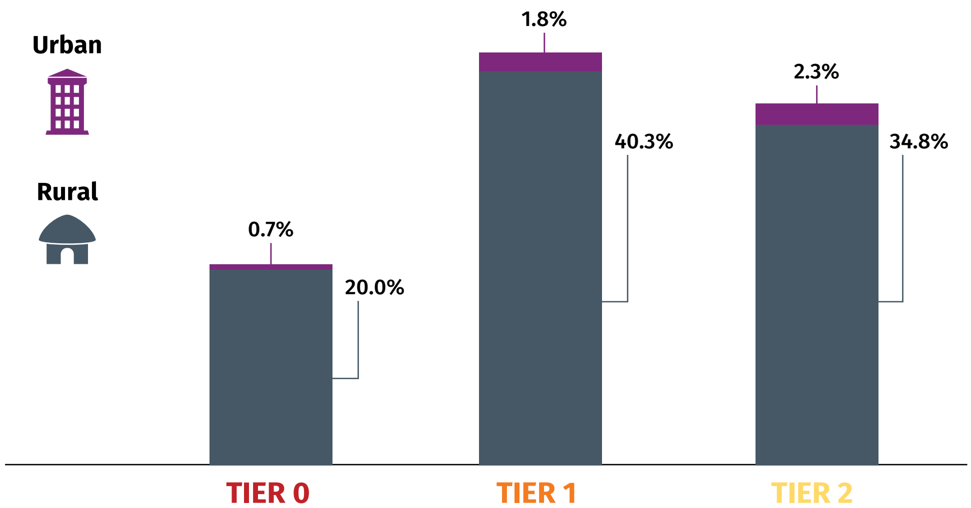
The use of off-grid solar solutions is relatively new in Myanmar. Among households that use these solutions, most obtained their first off-grid solar device within the last five years (96.7% of all off-grid solar users), and 74.4% did so within the last three years. The off-grid solar penetration rate has risen rapidly (Figure 32). Currently, 30.5% of households—61.1% of rural households and 11.0% of urban households—use off-grid solar devices as their main source of electricity.

FIGURE 32 • **Years of using off-grid solar solutions**



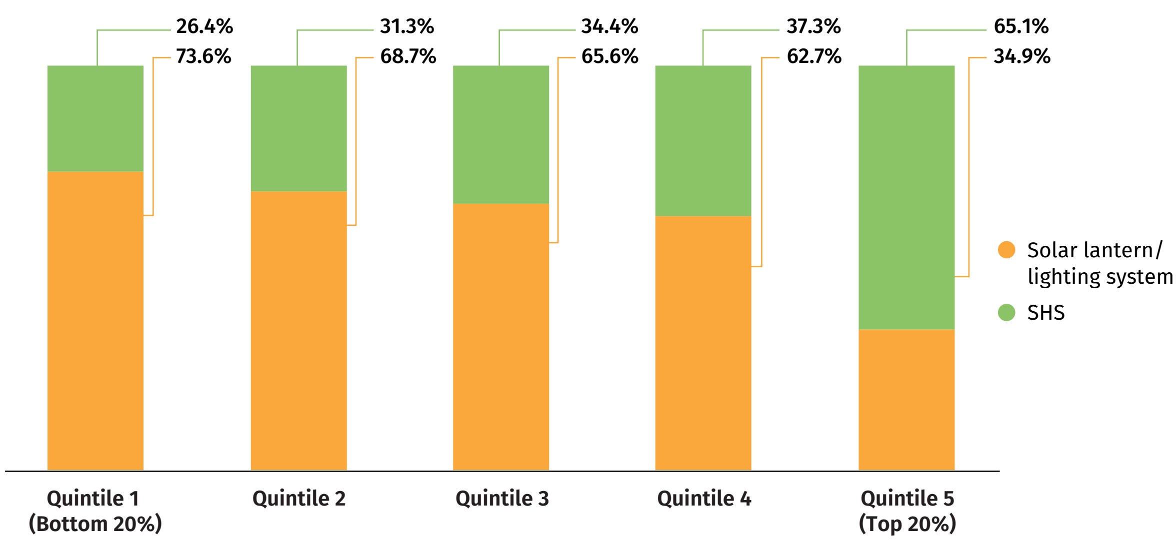
Among households that use off-grid solar devices, 20.7% are in Tier 0 because of limited Capacity; 42.1% are in Tier 1, meaning that they can power a very low load appliance, such as lighting, a phone charger, or a radio, and 37.1% are in Tier 2, meaning that a low-load appliance can be powered, such as a television or a fan (Figure 33; see Table 1 for the load levels associated with various appliances).

FIGURE 33 • **Distribution of households with off-grid solar solutions based on Capacity, urban/rural**



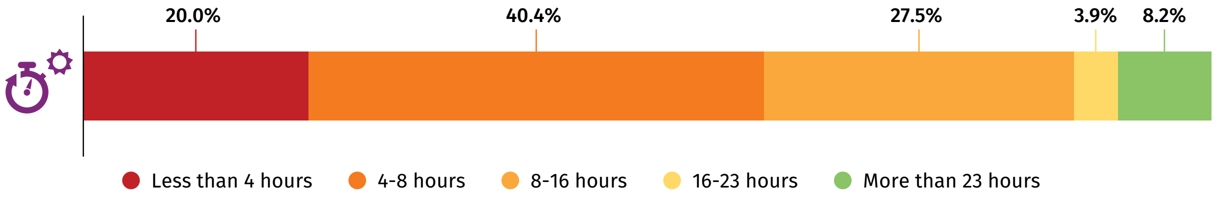
Households in the bottom quintiles tend to rely on a solar lantern or a SLS, while richer households can afford a SHS. SHS penetration rate increases dramatically in the top quintile, where 3 in 4 households own a SHS, whereas the rate ranges from 26.4% to 37.3% in the remaining quintiles. (Figure 34).

FIGURE 34 • **Distribution of off-grid solar solution typology, by expenditure quintile**



Among households with off-grid solar devices, 20% have less than four hours of electricity supply per day, and around 60% have less than eight hours (Figure 35). Nonetheless, about 71% of off-grid solar households have at least four hours of electricity supply during the evening.

FIGURE 35 • **Distribution of households with off-grid solar solutions based on Daytime Availability (over a 24-hour day)**

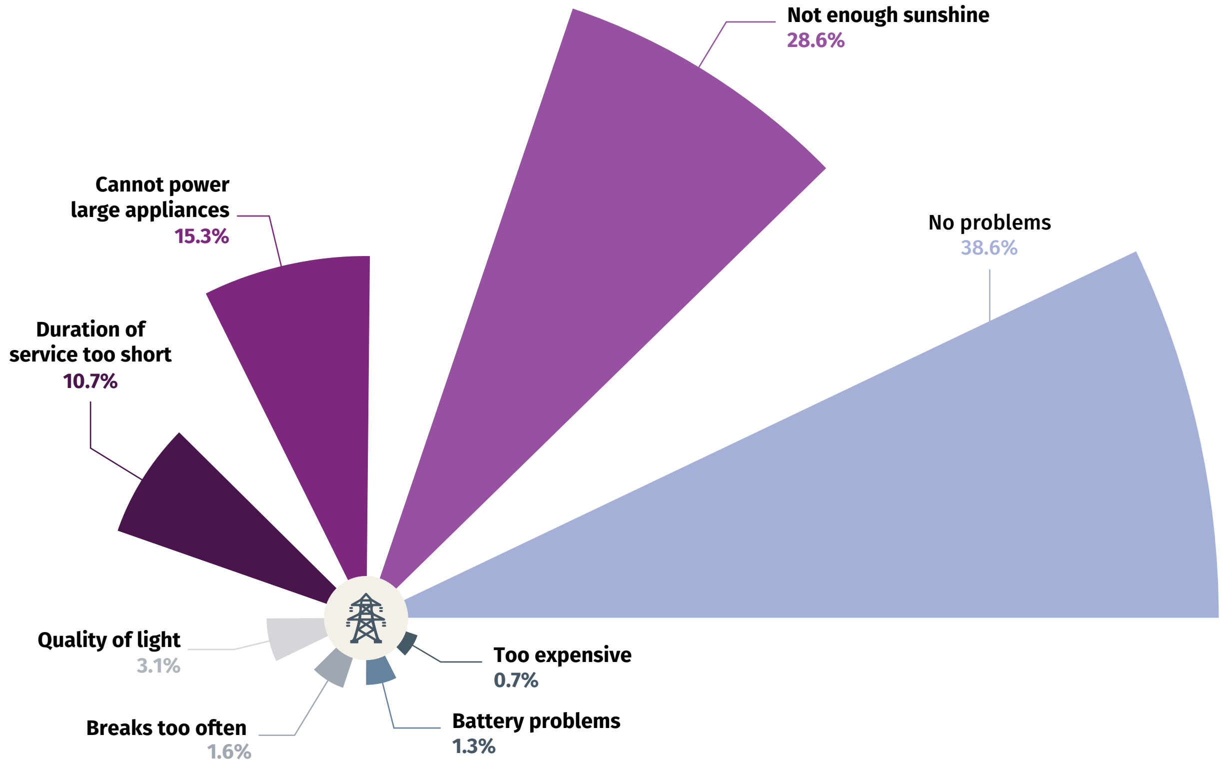


The priority in solar energy is to ensure that households relying on solar can achieve at least Tier 1 in access. Therefore, adequate and affordable off-grid solar products should be made available on the market. A solar device is adequate if the system can be used for lighting and to power very low load appliances for extensive amounts of time without hindrance from problems, such as failing batteries. Raising the awareness among nonelectrified households about the benefits of such devices is important. Moreover, households should be able to upgrade the system as their needs and their ability to pay increase. Households without electricity and households with poor-quality solar systems would profit from financing options enabling them to upgrade.

Around 39% of households relying on off-grid solar solutions are satisfied with their solar products. The main issues reported by other users are a lack of sufficient natural light (28.6%) and insufficient duration of service (10.6%) (Figure 36). These problems may be associated with the rainy season but could be addressed with higher-quality lightbulbs and off-grid solar products. A poor-quality or poorly maintained battery will fail quickly. This would create the perception that there is insufficient sunlight to charge properly, but the failure derives from the insufficient capacity and poor quality of the battery. The quality of close to 90% of pico-solar products[12] sold in Myanmar is not controlled (World Bank 2018c). These products tend to provide lighting services that are inconsistent in brightness and duration.

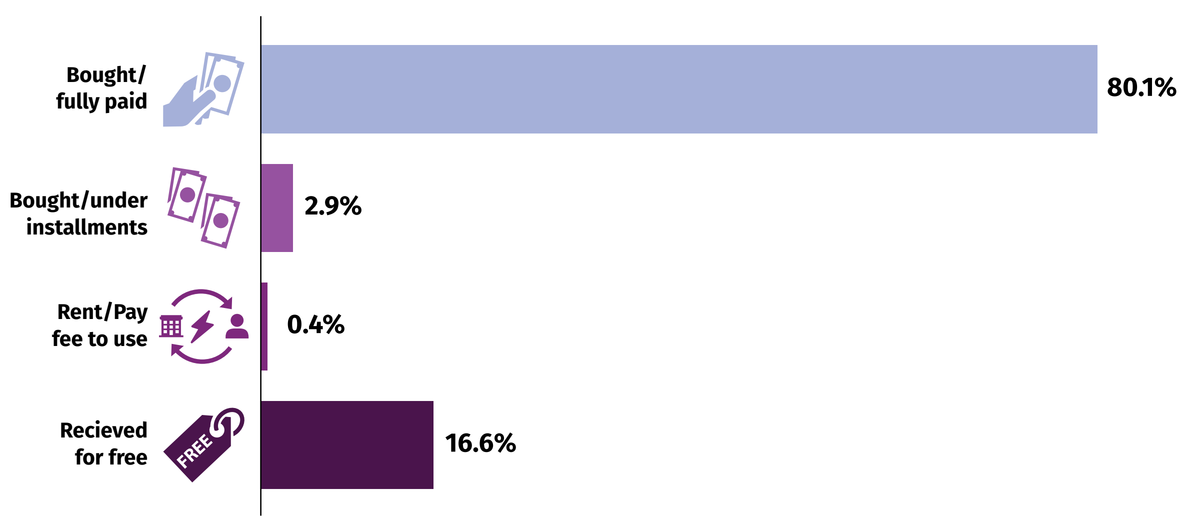
12 Pico-solar products include lanterns and simple multilight systems that may also enable mobile phone charging. Their peak photovoltaic module power may reach up to 10 watts.

FIGURE 36 • **Main issues related to off-grid solar solutions**



Among households that use solar devices, 83.0% purchased the devices (Figure 37). Of these, 80.1% paid the full price up front, and 2.9% paid in installments. Only 0.4% of households pay a fee or rent the devices, while 16.6% received the devices for free. Of this 16.6%, 78.0% of these beneficiaries received their solar products from local governments or the national government for free.

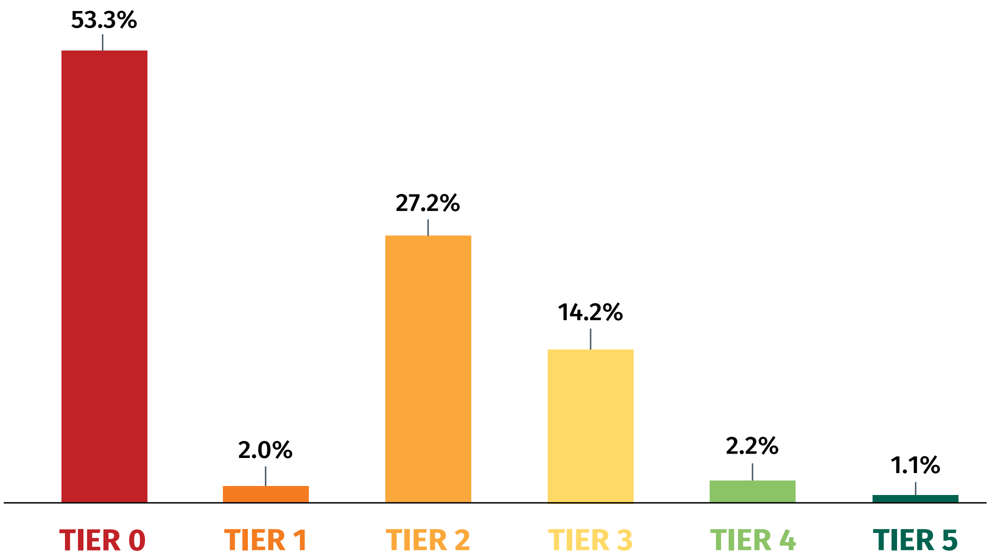
FIGURE 37 • **How off-grid solar products are acquired**



Households using mini-grids

Over half of mini-grid households are in Tier 0, while 40% are in Tier 2-3 (Figure 38). Mini-grids have the potential to provide Tier 3 access to households, provided that there is sufficient Capacity and electricity is supplied for at least 8 hours per day.

FIGURE 38 • **MTF tier distribution of households with mini grid access**



The majority of mini-grid users are constrained by Availability of supply: over 7 in 10 mini-grid households receive less than 8 hours of electricity per day (Figure 39). Most households with mini-grid access use electricity mainly for lighting during the evening. About 90% of households have more than three hours of electricity supply during this period (Figure 40). Improvement in the daily Availability attribute could potentially elevate more than half of households using mini-grids from Tier 0 to higher tiers.

FIGURE 39 • **Distribution of mini grid households based on Daily Availability (over a 24-Hour Day), nationwide**

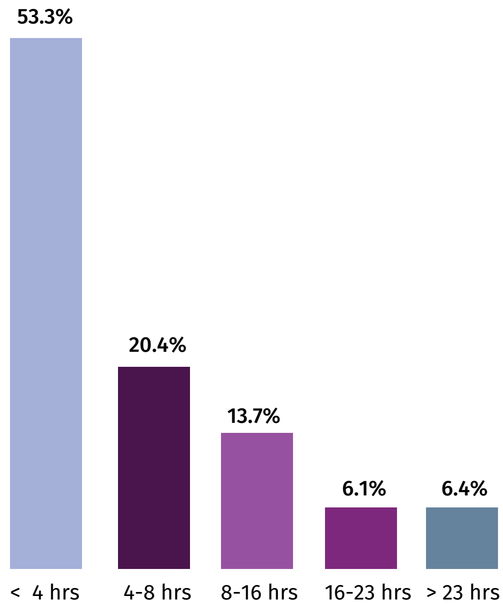
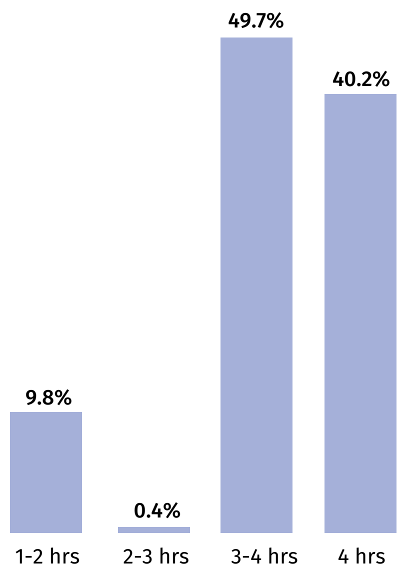


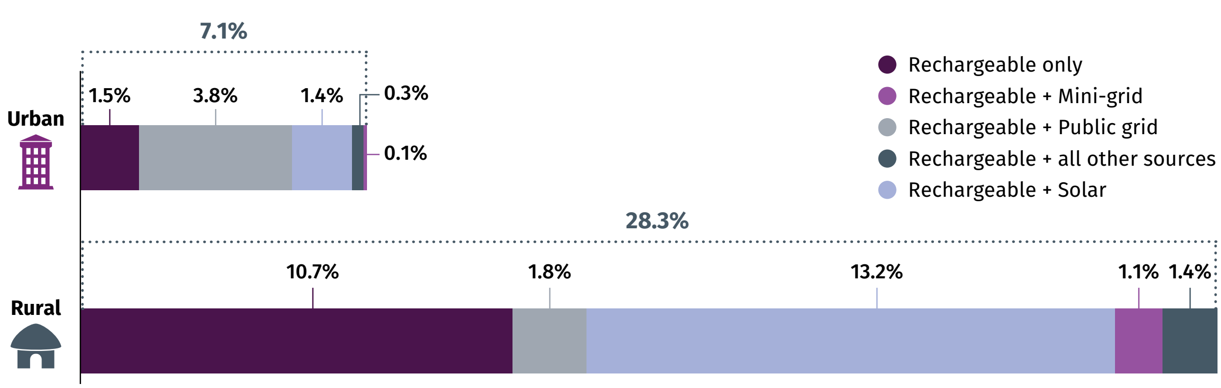
FIGURE 40 • **Distribution of mini-grid households based on Evening Availability (over a 4-hour period from 6 to 10 pm), nationwide**



Households using rechargeable batteries

Although 9.2% of households in Myanmar use rechargeable batteries as their primary electricity source, an additional 13.5% use them as back-up. The use of rechargeable batteries is more prevalent among households in rural areas (28.3%) than in urban areas (7.1%) (Figure 41). In rural areas, almost half of households using rechargeable batteries also use off-grid solar products. Among households that use rechargeable batteries as their primary electricity source 9.3% of them are in Tier 0 and 90.7% are in Tier 1, due to Availability and Capacity constraints. To elevate these households into higher tiers, they will need to get electricity access through other type of technologies which can power higher capacity of energy service for longer hours.

FIGURE 41 • **Access to rechargeable batteries, urban/rural**



POLICY RECOMMENDATIONS

More than one-third of households are connected to the national grid. Improving Quality and Reliability of the electricity supply, by addressing voltage issues and reducing outages, would shift two-thirds of grid-connected households to higher Tiers 4–5.

A substantial share (48%) of households use off-grid solutions, including stand-alone solar devices, mini-grids, and rechargeable batteries. About a third of them (32.7%) are in Tier 0 due to Capacity and Availability. Thus, addressing these limitations could shift a third of households relying on off-grid solutions to higher tiers.

About 13.5% of households in Myanmar have no access to any source of electricity, while an additional 16.2% fall in Tier 0 access because of the limited Capacity and Availability of their electricity supply. Moving up the 13.5% of households without any source of electricity would require connecting these households to the grid or providing them with off-grid solutions. Policy recommendations for providing electricity are as follows:

- Optimal energy solutions at the lowest cost need to be formulated in light of population density, distance to the national grid network, the potential electricity demand of various types of customers, and the socioeconomic environment. Because of advances in geographic information system technology, optimal energy solutions are often devised based on geospatial planning.
- Grid densification, especially by offering payment plans for the connection costs and a variety of financing options would effectively address the household financial barrier represented by the connection fee. Improving administrative procedures can potentially also help more nonelectrified households connect to the grid. Likewise, an expansion in grid infrastructure can supply electricity to those as long as this is the least costly approach.
- Off-grid solar products could help households in villages in which the grid infrastructure is not yet available. Strengthening quality control systems, coupled with microfinancing and leasing opportunities, might boost the adoption of solar devices. Consumer awareness programs would help potential customers choose good-quality of products and use them more sustainably.
- Minigrids should be expanded in places where they represent the least costly option. New mini-grids should address the supply problems in current mini-grids to promote higher tiers of service. The majority of households currently relying on mini-grids are constrained by the insufficient Availability of the electricity supply (less than 8 hours a day). By hybridizing with renewable energy sources such as hydro or solar, Availability could be improved, thereby promoting the shift of Tier 0 households with mini-grids to higher tiers. Improvement in the mini-grid regulatory framework would foster more private investment.

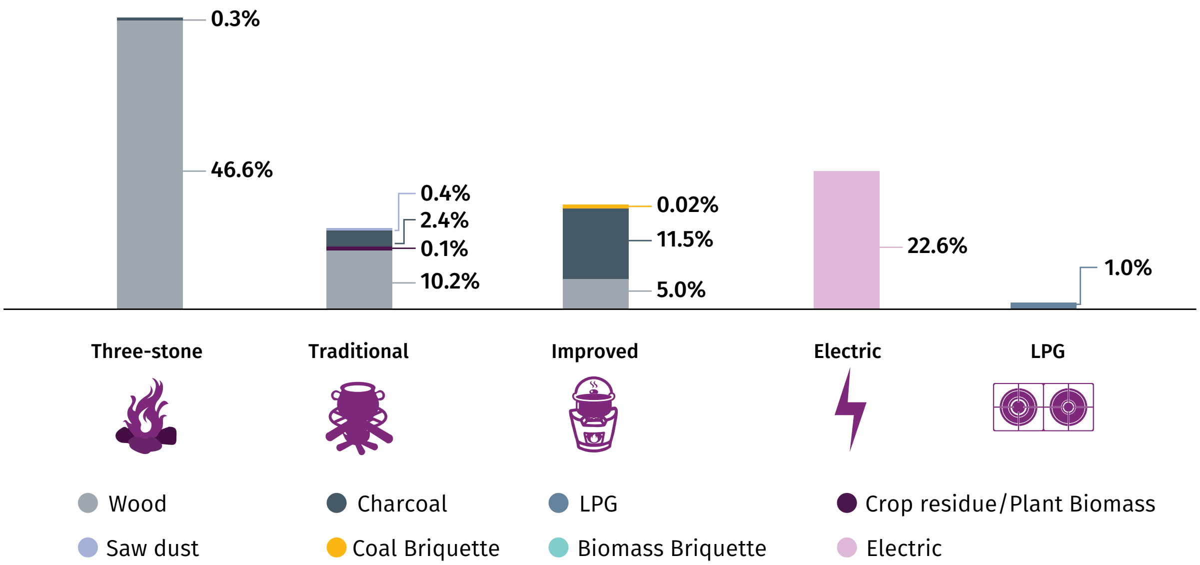
ACCESS TO MODERN ENERGY COOKING SOLUTIONS

ASSESSING ACCESS TO MODERN ENERGY COOKING SOLUTIONS

TECHNOLOGIES

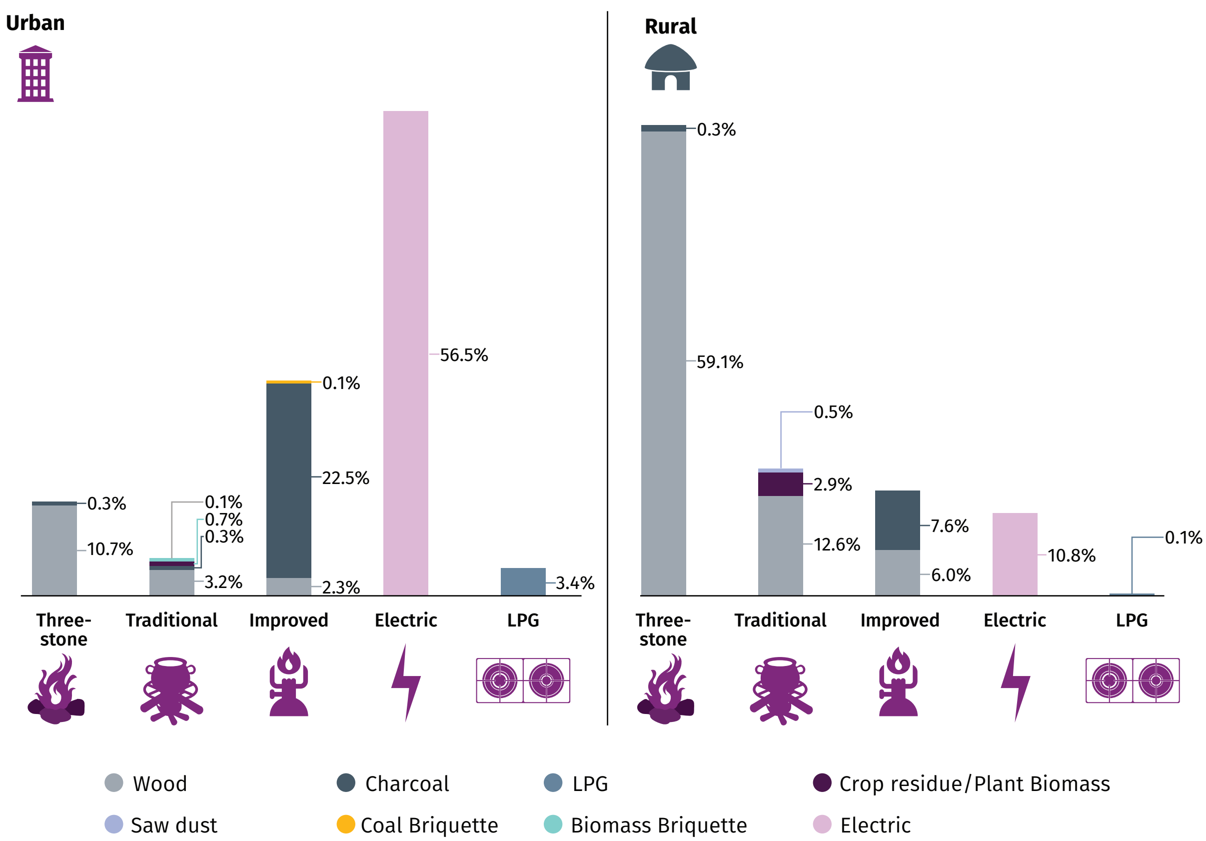
In Myanmar, over 73% of households cook with biomass (Figure 42). About 46.9% of the households use a three-stone stove as their primary cooking solution, mainly burning firewood (46.3%). Improved cookstoves are used by 16.5% of households, and clean fuel stoves (mainly electric stoves) are the primary cooking solution of 23.6% of households.

FIGURE 42 • **Distribution of cookstoves and fuel used, nationwide**



Urban and rural households have different cooking patterns. Urban households cook predominantly with electricity (56.5%), followed by charcoal (22.5%) (Figure 43). In urban areas, more than half of households (59.9%) use clean fuel stove, 56.5% using electric stoves and 3.4% using LPG stoves as their primary cooking solution, followed by 24.9% of households that use improved cookstoves. More than three quarters of rural households cook predominantly with firewood (77.7%). Over 60% of rural households use a three-stove stove (59.4%), while about 14% use an improved cookstove and 10.9% a clean fuel stove.

FIGURE 43 • **Distribution of cookstoves and fuel used, urban/rural**

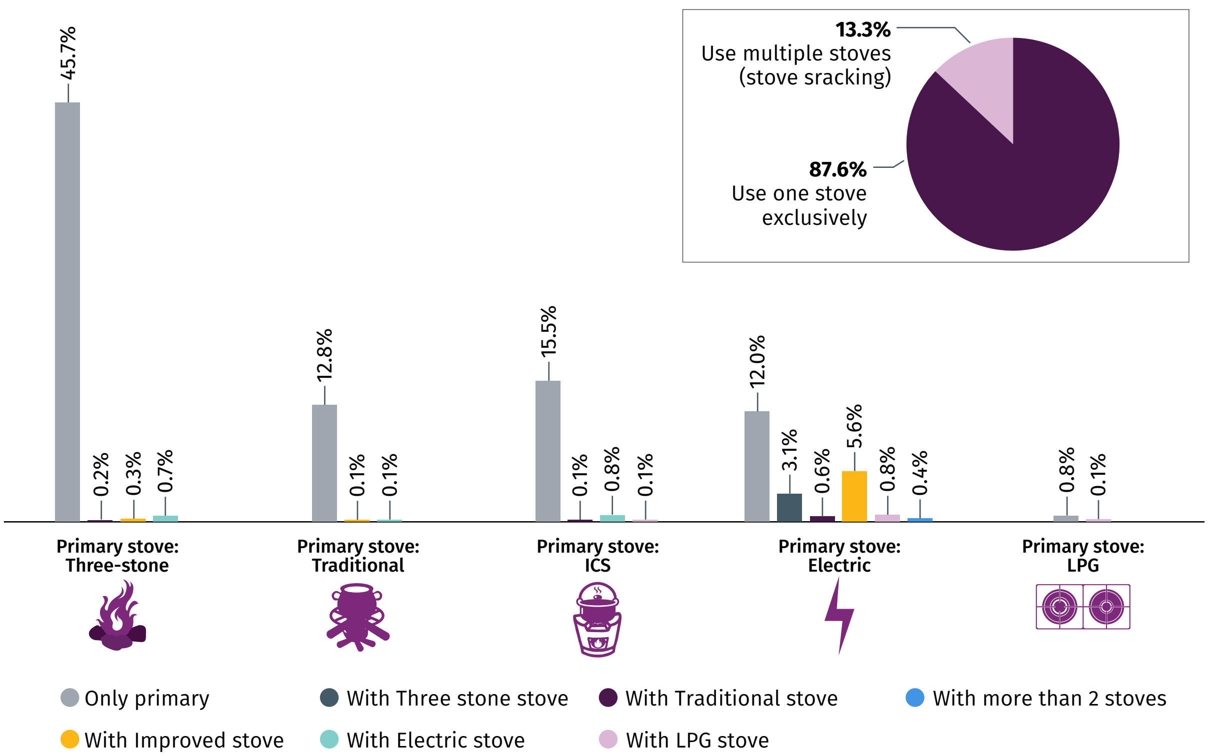


Stove stacking is not common in Myanmar: less than 14% of Myanmar households use multiple stoves to meet their cooking needs. Almost half of all households use three-stone stoves exclusively (45.6%). Traditional stoves (12.8%), ICSs (15.4%), and electric stoves (12.0%) are also used as the only cookstoves in the home. Liquefied petroleum gas (LPG) stoves are used exclusively by 0.8% of households. Such stacking is more common in urban areas (26.5%) than in rural areas (8.0%) (Figure 45). In urban areas, 18.7% of households use electric stoves, along with improved biomass stoves (Figure 46).

The most frequent stove stacking combination refers to households that primarily cook with an electric stove and also use an improved stove (5.6%), followed by households cooking with electric stoves while using in parallel a [cookstove] (3.1%) (Figure 44).

In addition to the 12.0% using electric stoves exclusively, another 11.4% use electric stoves, along with biomass stoves. The use of electric stoves is prevalent in urban areas, where 33.8% of households use electric stoves only, and 22.4% use electric stoves, along with biomass stoves. However, exclusive use of a three-stone stove is the most prevalent cooking method in Myanmar, mainly because of the prevalence in rural areas (Figure 44).

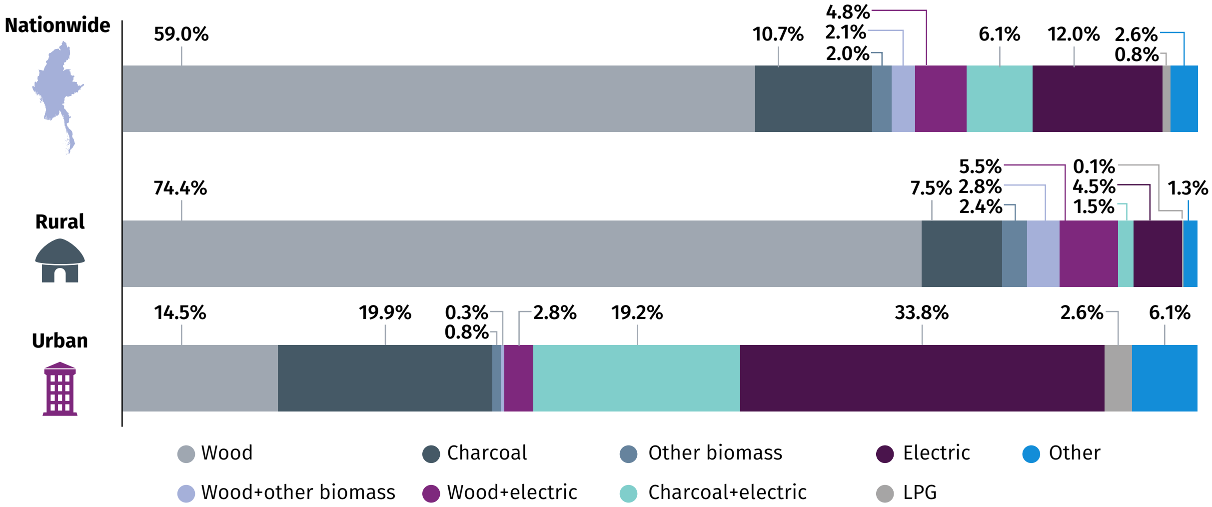
FIGURE 44 • **Stove stacking by primary stove type, nationwide**



Consistent with the wide disparity in stove types between rural and urban areas, fuel use also differs widely. Much of the disparity may be attributed to the higher percentage age of urban households connected to the grid. In urban areas, where 85.3% of households have grid electricity, 60.0% use electric stoves, whereas only 12.1% of rural households use this type of stove as a primary or secondary stove. Most rural households use firewood (74.4%) as the primary cooking fuel.

Among urban households using one biomass cooking fuel exclusively, more use charcoal (19.9%) than firewood (14.5%). This is also the case among households using more than one fuel. The most common combination of fuels among urban households are charcoal and electricity (19.2%), whereas, among rural households, it is wood and electricity (5.5%). The use of LPG is limited; the exclusive use of LPG is more prevalent among urban households, at 2.6% (Figure 45).

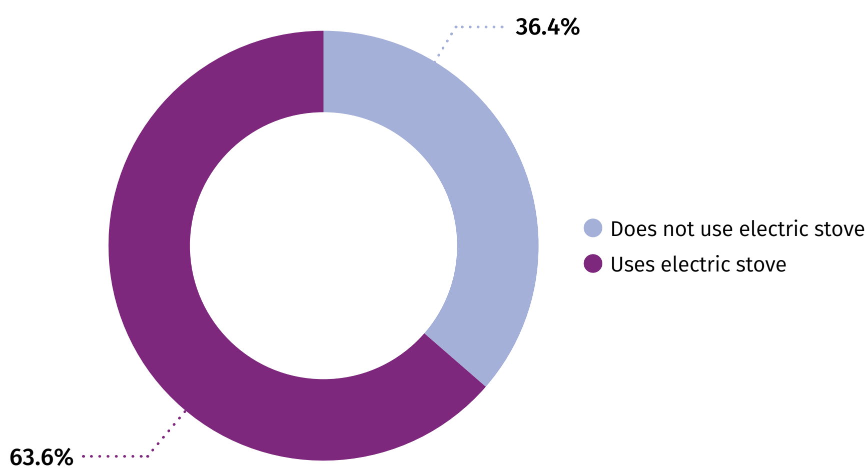
FIGURE 45 • Cooking fuel stacking (nationwide, urban/rural)



Note: Fuel stacking is the practice of using more than one type of fuel to meet household cooking energy needs. For more on the origins of and reasons for fuel stacking, see Bhatia and Angelou (2015).

Nationwide, among grid-connected households, 63.6% use electric stoves (Figure 46).[13] A reason for the popularity of electric stoves is linked to the low electricity tariff in Myanmar.

FIGURE 46 • The penetration rate of electric stoves among grid-connected households

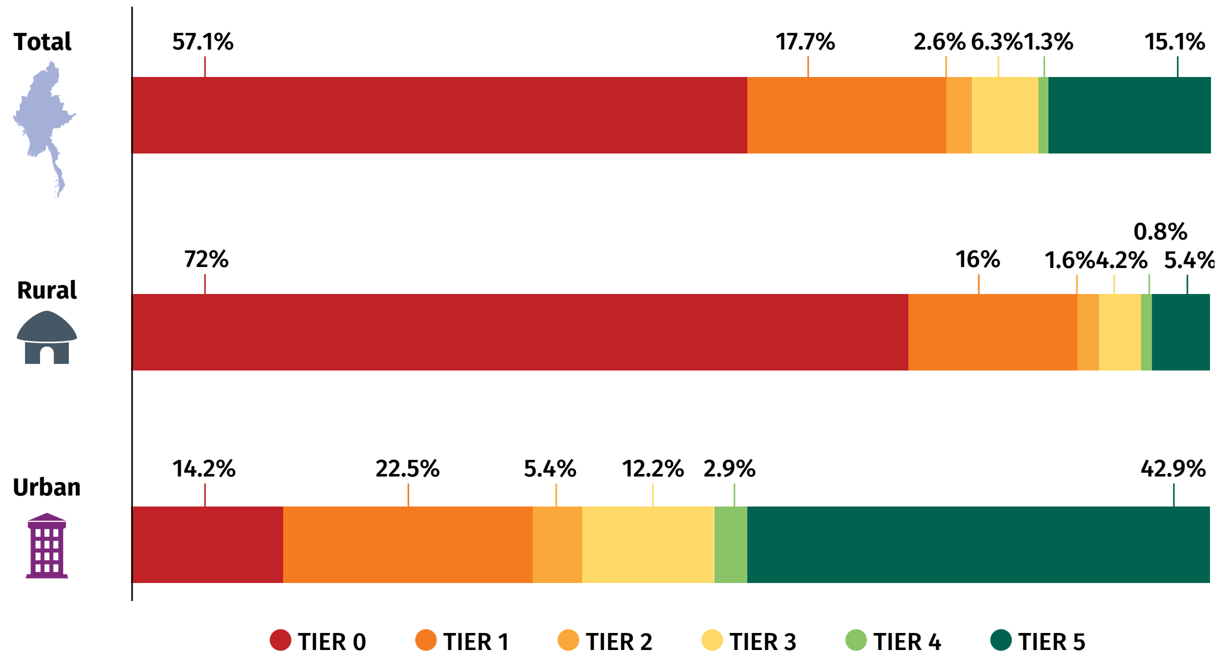


13 The multi-purpose electric pan is the electric stove most widely used in Myanmar.

MTF TIERS

Slightly less than one quarter (22.7%) of households in Myanmar are in Tier 3 or above; 16.4% are in Tiers 4 or 5 (Figure 47). A significant gap between urban and rural households has been identified in MTF cooking tier distribution: only 14.2% of urban households are in Tier 0, compared with 72.0% of rural households. The gap between urban and rural households is wide in Tier 5: 42.9% of urban households are in this tier, compared with 5.4% among rural households.

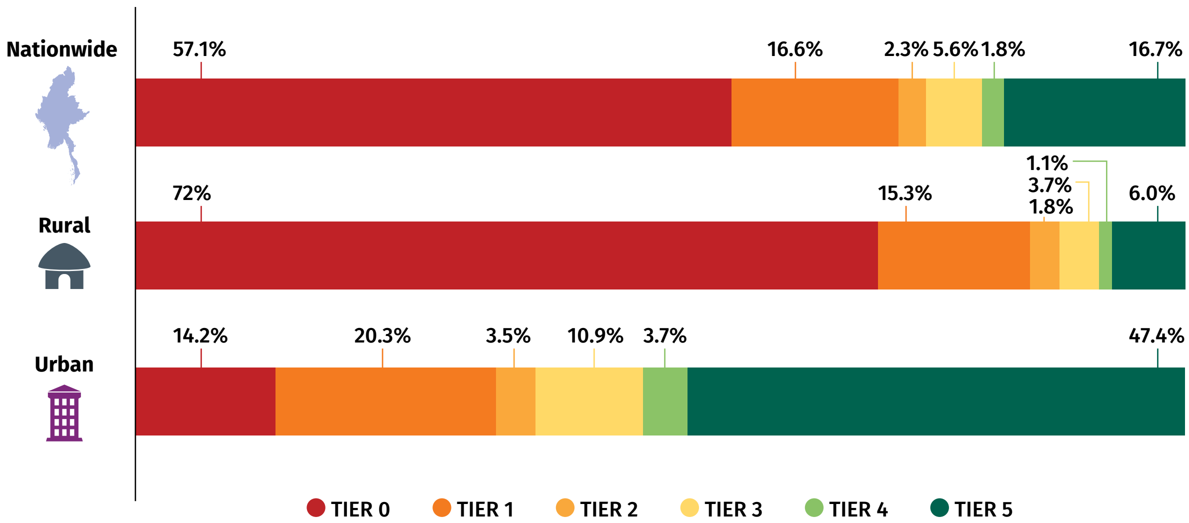
FIGURE 47 • **MTF Tier distribution: access to modern energy cooking solutions (nationwide, urban/rural)**



Cooking Exposure

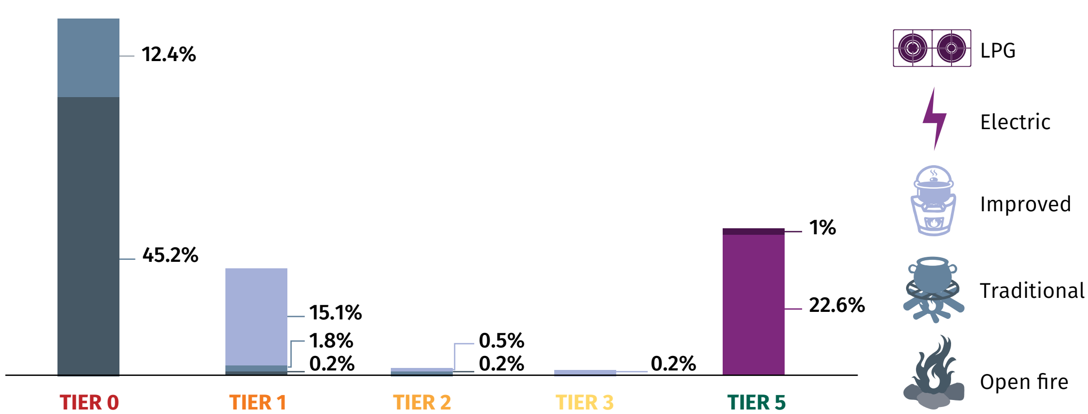
For the Cooking Exposure attribute, which represents an estimate of personal exposure during cooking activities based on the emissions of cooking and the ventilation, 57.1% of households are in Tier 0, mainly because of the high stove emissions. The tier associated with Cooking Exposure is negatively affected by the fact that 72.1% of households use biomass stoves without sufficient ventilation. Substantially more urban households are in Tiers 4–5 (51%) relative to rural households (7.1%). This is largely attributed to the substantial penetration of electric stoves and their nearly exclusive use in urban areas (Figure 48).

FIGURE 48 • **Distribution of households based on Cooking Exposure (nationwide, urban/rural)**



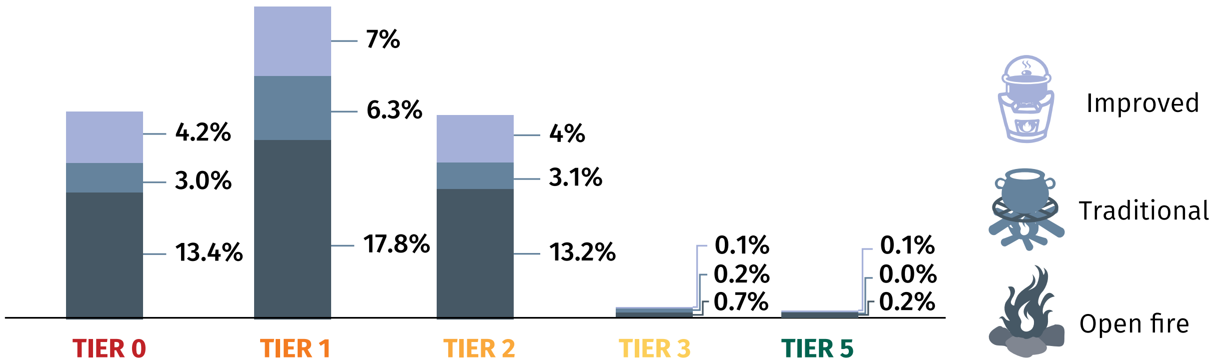
Households using three-stone stoves as their primary stoves account for the largest share of Tier 0 for the Cooking Exposure attribute. A small portion of primary stoves (1.8%) that are three-stone stoves reach Tier 1, which derives from the better ventilation. Households using an ICS are typically classified Tier 1 for Cooking Exposure. Few biomass stoves achieve Tier 2 or 3 in exposure because of the absence of advanced biomass stoves, such as gasifier stoves, that can reduce pollutants significantly (Figure 49).

FIGURE 49 • **Distribution of households based on Cooking Exposure and primary stove type**



The Ventilation tier, only relevant for biomass fuel stoves, mostly ranges from Tier 0 to Tier 2. The bad ventilation tiers result from the fact that many households cook in small indoor spaces with no or few openings. The absence of Tier 4 in ventilation structure indicates that households do not use fans or hoods as exhaust systems in kitchens (Figure 50). Most of households (about 7 in 10) cooking with biomass stoves have either no window (Tier 0) or just one window (Tier 1) in their kitchen (Figure 52). Three in 10 households have at least one window (Tier 2). A very small share of households have significant openings in their cooking space (Tier 3), none cook on a veranda (Tier 4) and almost none cook in the open air (Tier 5).

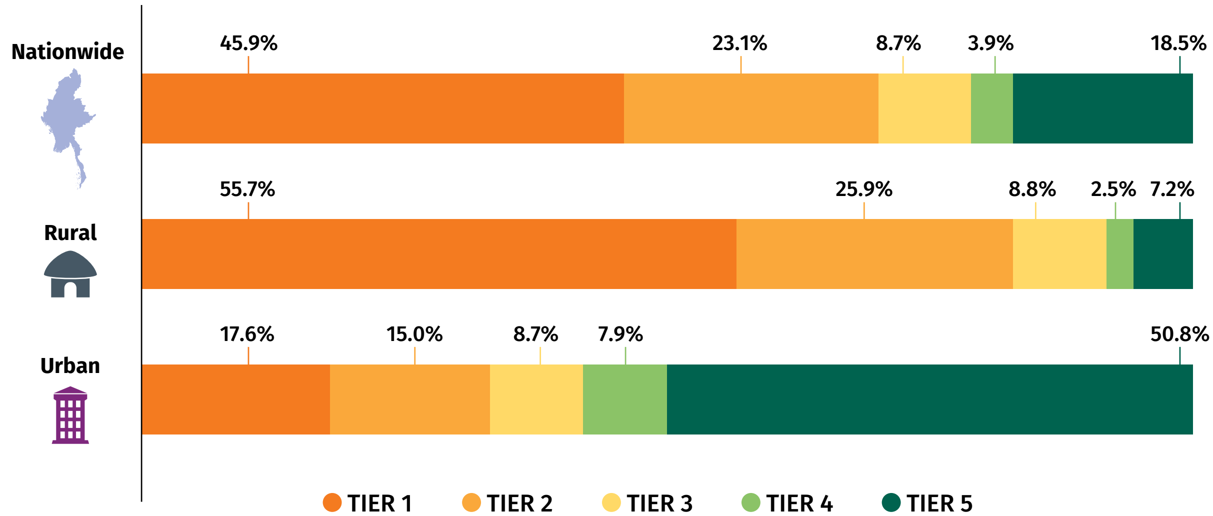
FIGURE 50 • **Distribution of households based on primary stove type and ventilation tier**



Convenience

Convenience is determined by the time spent collecting and preparing fuel per week and preparing the stove for cooking per meal. In Myanmar, 45.9% of households spend more than seven hours a week in fuel collection and at least 15 minutes in stove preparation per meal (Figure 51).

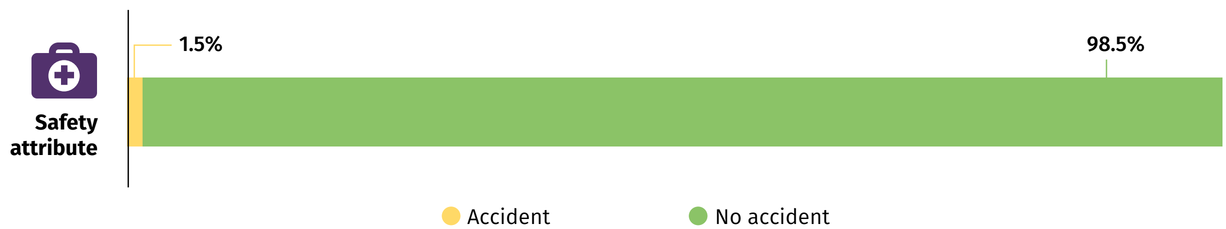
FIGURE 51 • **Distribution of households based on Convenience (nationwide, urban/rural)**



Safety of Primary Cookstove

The degree of risk of injury varies by type of cookstove and the fuel used. Risks may include exposure to hot surfaces or fire or the potential for fuel splatter. In defining this attribute, the reported incidence of past injury or fire are used to measure safety. If no accidents requiring professional medical attention was reported in the year prior to the survey, then the cooking device was considered safe. This was the observed case in 98.6% of households (Figure 52). Of the 1.4% of households reporting accidents, 89.1% were using three-stone stoves.

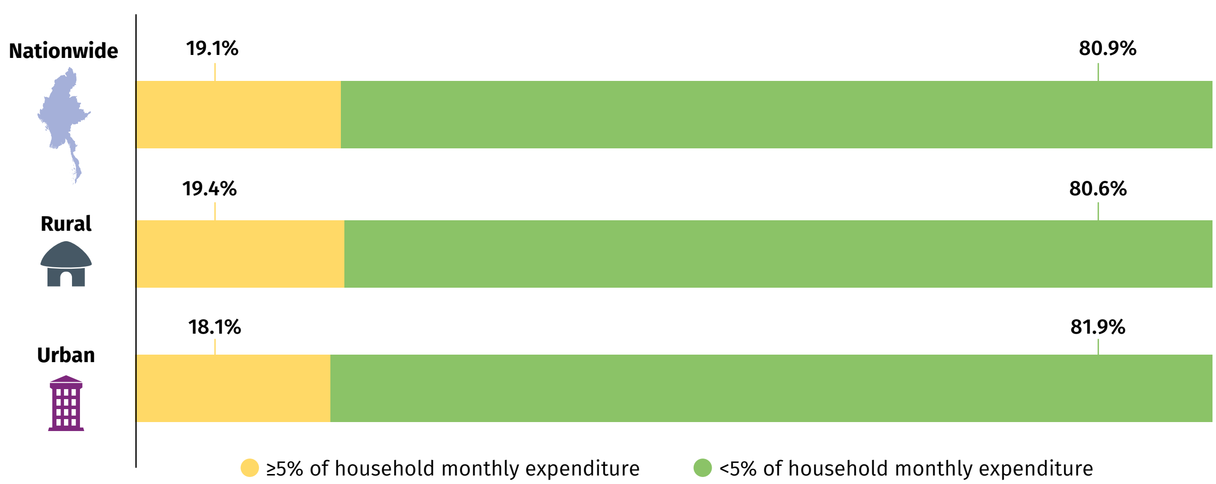
FIGURE 52 • **Distribution of households based on Safety**



Affordability

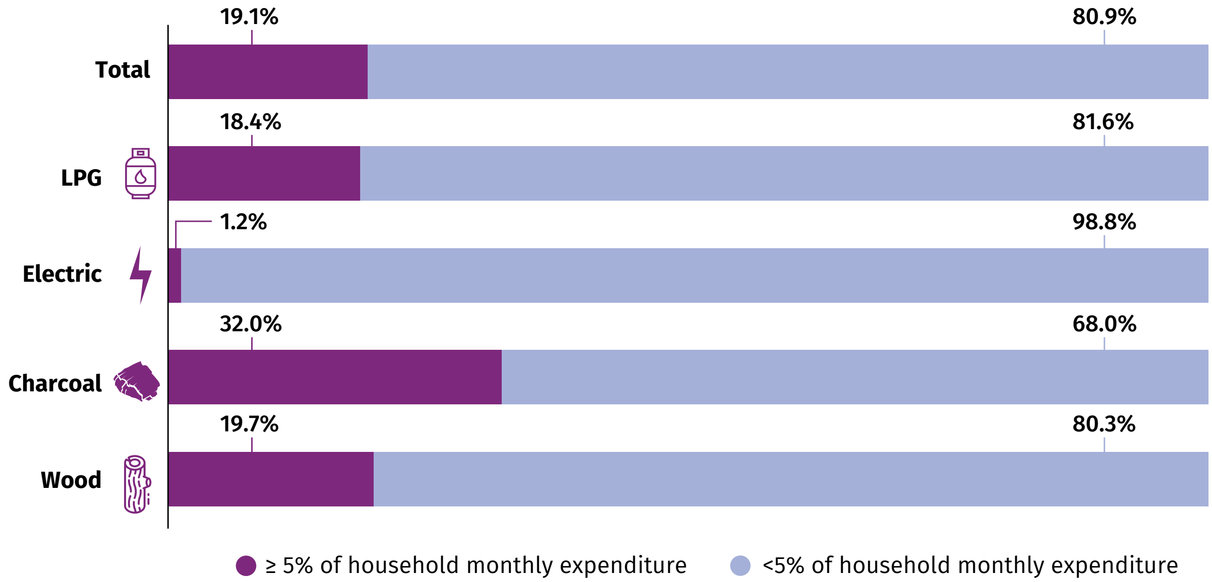
The Affordability attribute is calculated using two factors, total monthly household expenditure and household expenditure on cooking fuel. If a household's expenditure on cooking fuel does not exceed 5% of household monthly expenditure, the fuel is considered affordable. According to this criterion, one-fifth of households in Myanmar reported that their current cooking solution is not affordable. No significant difference in Affordability was identified between urban and rural households (Figure 53).

FIGURE 53 • **Distribution of households based on Affordability (nationwide, urban/rural)**



Almost all households cooking primarily with electric stoves reported that electricity for cooking was affordable[14] (Figure 54). This result is closely linked to the fact that grid-connected households tend to be wealthier than the rest and that electricity tariff is low[15]. Cooking with LPG is considered affordable for 81.6% of households that use a LPG stove. Wood based cooking shows same level of results, while only 68% of households cooking with charcoal reported that charcoal is affordable for them.

FIGURE 54 • **Household distribution of the Affordability attribute, by fuel type**



IMPROVING ACCESS TO MODERN ENERGY COOKING SOLUTIONS

The ultimate objective of improving access to modern energy cooking solutions should be to facilitate access among all households to cooking solutions that are clean, convenient, efficient, affordable, safe, and available. An increase in the rate of adoption of clean fuel stoves, such as electric or LPG stoves, could boost households to higher tiers. In addition to clean fuel stoves, the promotion of using an ICS could help shift households, particularly Tier 0 households, to higher tiers.

FOSTER A SHIFT FROM BIOMASS FUEL STOVES TO ELECTRICITY OR LPG STOVES

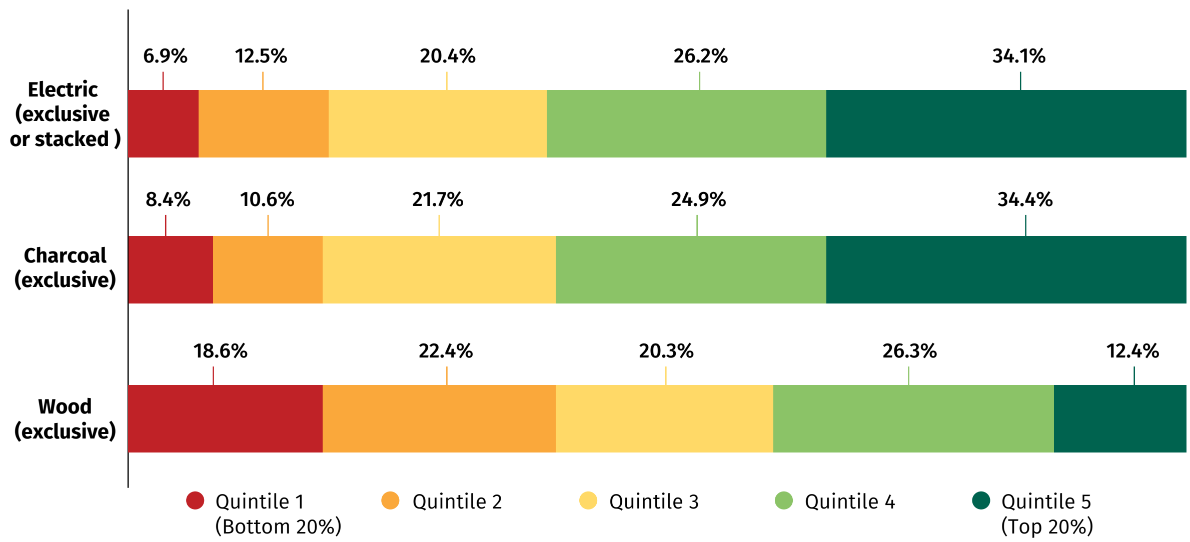
Given the substantial penetration of electric stoves and the low price of electricity, particularly in urban areas, the share of households using electric stoves would likely rise as more households gain access to the grid. Among households using electric stoves exclusively, 1.2% spend more than 5% of

14 The amount of electricity used for cooking was approximated based on assumptions on the level of energy required for cooking, and the energy efficiency of common electric stoves used in Myanmar.

15 Households pay 35 MMK/kWh if they use less than 100 kWh's a month.

their monthly budgets on the purchase of cooking fuel, while 18.4%–32.0% of the households relying on other fuels use over 5% of their budgets on cooking fuel (Figure 55). Grid-connected households are in a higher income bracket than unconnected households, but low electricity prices are also important in understanding high Affordability of cooking with electric stoves. Also, grid-connected households using electric stoves tend to be better off than grid-connected households that do not use electric stoves (Figure 55). This may indicate that the up-front cost of purchasing an electric stove is burdensome. Availing more affordable and efficient electric stoves could make this stove more popular among grid-connected households.

FIGURE 55 • **Distribution of grid-connected households by cooking fuel and expenditure quintile**



Grid-electrified households that do not use electric stoves may not be aware of the benefits of using electric stoves. The grid-connected households using charcoal as the primary fuel are not substantially different from the households using electric stoves in terms of monthly expenditure, which is a proxy for household financial well-being. About two-thirds of the grid-connected households using charcoal stoves reported that they were not willing to pay for an ICS because they did not need a new stove (36%) or they did not need an improved stove (36%). The lack of interest in an improved stove could be interpreted as the lack of awareness of the benefits of cleaner and more efficient cooking solutions. Thus, bringing awareness to the benefits of using electric stoves will likely help promote their use and adoption.

The popularity of electric stoves has been linked to Myanmar's low electricity cost. With the extension and densification of the grid network under the National Electrification Plan, it is likely that more grid-connected households will switch to electric stoves. Satisfying the demand for electric stoves should be met with careful planning. Electrification planning should consider cooking using electricity, incorporating associated costs with this usage. Because electric cooking contributes to peak demand, anticipating its impact should be considered in electrification and network planning. These actions will be critical to maintaining the availability, reliability, and quality of electric service. Were there to be an increase in the electricity tariff, measures will need to be taken to make other clean cooking alternatives, such as LPG, and more efficient electric stoves, to be more affordable and available. Doing so would help ensure that users would return to using biomass stoves.

Another consideration should be the government's plans to raise the production and imports of LPG. The new supplies of LPG would be used to generate electricity and meet domestic and industrial energy needs (Kyaw 2018). If effectively implemented, these plans would make LPG more accessible and affordable for households, thereby offering another path to clean cooking in addition to electricity. Furthermore, given that a large part of the future energy generation mix will be LPG, it will become less efficient for households to use electricity generated with LPG instead of burning LPG directly.[16]

INCREASING THE USE OF IMPROVED COOKSTOVES AS THE PRIMARY COOKING SOLUTION

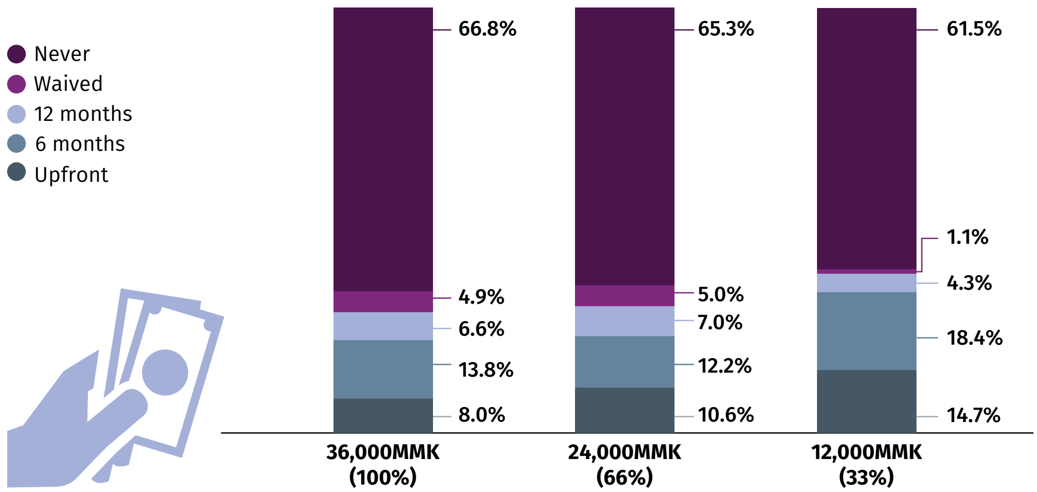
Increasing the use of ICSs is the most feasible and immediate solution for households that use three-stone or traditional stoves, particularly in rural areas, and among which switching to clean fuel stoves (electricity or LPG) is not feasible because fuel is not available or affordable. More than three-quarters of rural households use three-stone (59.4%) or traditional stoves (16.1%) as their primary stove. Virtually all these households are in Tier 0 or 1, mainly because of the Cooking exposure and Convenience attributes.

The potential benefit of switching is not as significant in the case of ICSs as in the case of clean fuels, but it is still substantial, particularly because of greater energy efficiency that leads to reduction in expenditures on fuel, time spent obtaining fuel, and exposure to fumes from the cookstove.

Offering a payment plan over time can effectively increase the adoption of ICS among households that use three-stone or traditional stoves. Households were asked whether they would pay the full or reduced price for an ICS (36,000 MMK / 26 USD) (Figure 56). Reducing the price increases the WTP only moderately. An additional 1.5% and 3.8% of households were willing to pay for an ICS if the price is presented at two-thirds or one-third of the full price, respectively. These findings reveal that a more effective strategy for expanding the adoption of ICS is to offer a payment plan rather than reducing the price of an ICSs. An extra 25.3% of households were willing to pay for an ICS at full price under a payment over 6, 12, 24 months. However, almost two-thirds of the households that use three-stone or traditional stoves are not willing to pay for an ICS under any price or payment option.

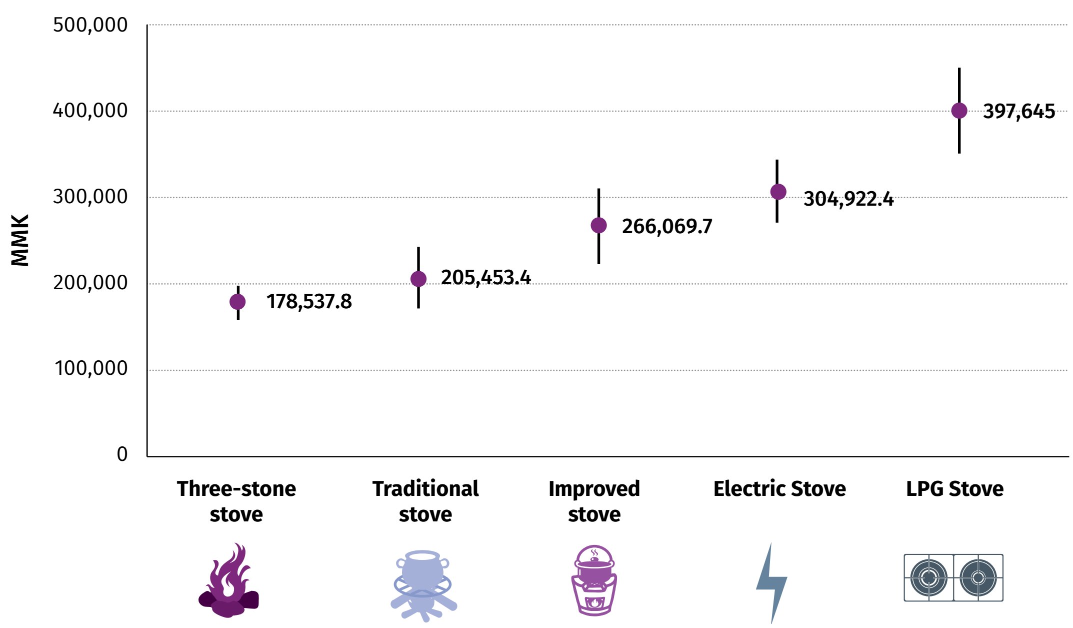
16 The gas to power conversion efficiency is 30% according to a World Bank estimate based on Electric Power Generation Enterprise statistics.

FIGURE 56 • **The WTP for an improved biomass stove**



The average monthly expenditure is lower among households that use three-stone or traditional stoves than among households using LPG, electric, or an ICS. Purchasing an ICS at the full up-front cost may thus be financially burdensome for the former (Figure 57).

FIGURE 57 • **Average monthly household expenditure by stove type, households using one stove type (exclusive use)**



Most households not willing to pay for an ICS under any price or payment plan (87%) reported that they do not need an ICS or any kind of new stove. Affordability is an issue for 11.7% of households. Thus, along with enhancing access to financing and innovative business models, advertising and public awareness campaign on the benefits of using ICSs could help increase adoption (Figure 58).

FIGURE 58 • **Reasons households are not willing to pay for an improved cookstove**

POLICY RECOMMENDATIONS

Promote the switch from biomass fuel stoves to electric or LPG stoves.

- Grid-connected households would be more likely to adopt electric stoves if the price of electricity remains affordable and less-expensive electric stoves become available on the market, along with an enhanced awareness of the benefits of clean fuel stoves.
- If electric stoves are promoted and the price of electricity remains low, the growing demand for electricity for cooking should be considered in electricity generation and network expansion planning. It is also recommended that the promotion of efficient electric stoves be explored to offset the rise in electricity demand and expenditure.
- The use of LPG stoves can substantially reduce the emission of indoor air pollutants. Wider adoption of these stoves should therefore be considered. The potential for increasing the adoption of LPG stoves should be analyzed with an emphasis on fuel availability and affordability. Based on the results of the analysis, a comprehensive and systematic plan and strategy should be devised that cover both the supply side and the demand side.

Increase the use of ICSs as the primary cooking solution among households that cannot afford clean fuels or do not have clean fuel options available.

- The full up-front cost of ICS would be financially burdensome for households currently using three-stone or traditional stoves. Offering a payment period or reducing the up-front cost would increase the adoption of ICSs.
- Along with enhancing access to financing and innovative business models, advertising and enhancing public awareness of the benefits of using an ICS are important.
- The promotion of advanced biomass stoves, for example, gasifier biomass stoves, that could reduce pollutant emissions significantly should be explored.

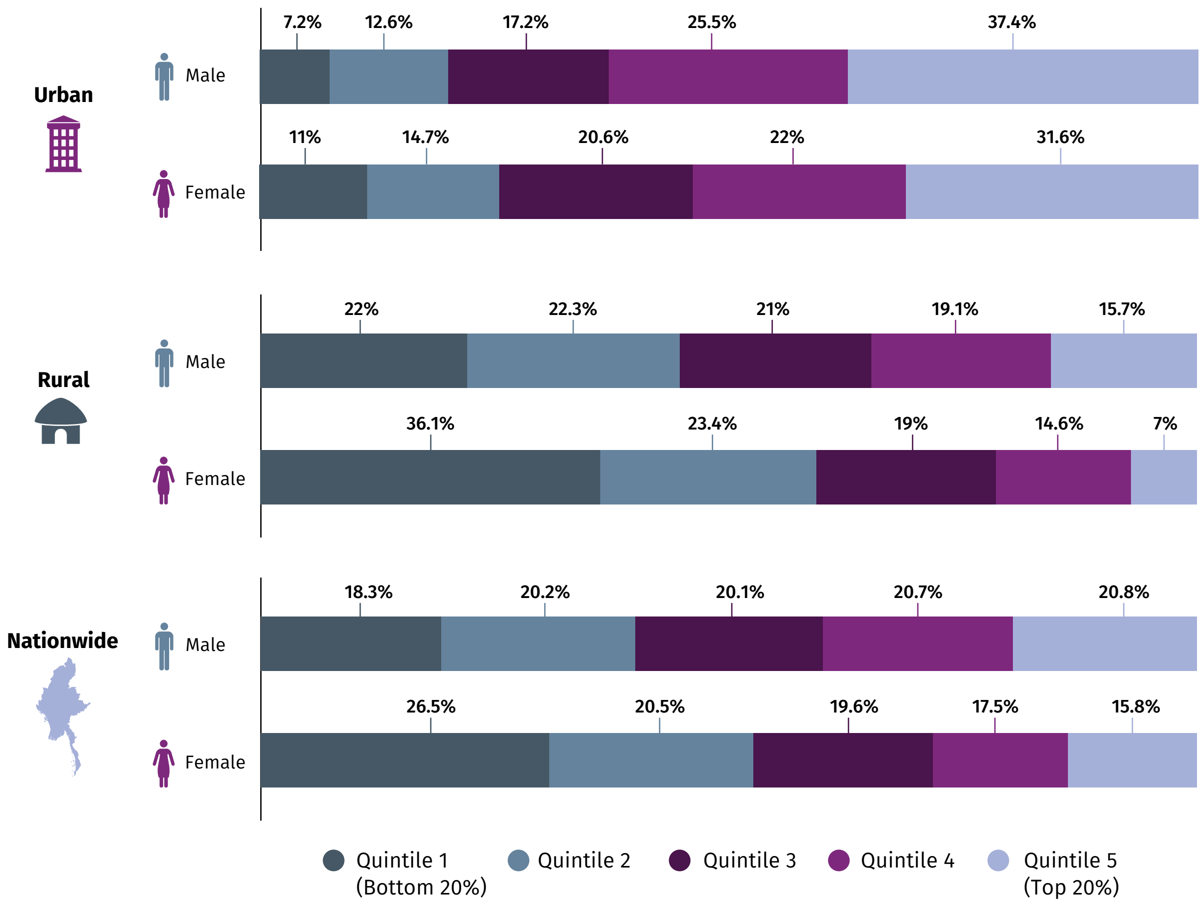
GENDER ANALYSIS

Nationwide, 18.1% of households are headed by women (Figure 59). The average age of female household heads is 60.4 years, compared with 48.4 years among male household heads. The average size of female-headed households is 4.1 members compared to 4.7 members for male-headed households. Female-headed households account for 15.8% of rural households and 25.3% of urban households.

FIGURE 59 • **Distribution of female- and male-headed households**

Female-headed households are overrepresented in the lowest quintile and underrepresented in the higher quintiles (Figure 60). This gap is even wider in rural areas. The average household expenditure is lower for female-headed households (201,264 MMK/148 USD per month) than for male-headed households (236,004 MMK/173 USD per month). Also, male heads of household have higher educational attainment than their female counterparts. More than a quarter of female household heads (27.3%) reported that they never attended school; this is 16.9% higher than the 10.4% of male household heads so reporting. Only a quarter of male household heads had completed primary education, while 18.2% of female household heads had done so.

FIGURE 60 • **Distribution of male- and female headed households, by expenditure quintile (nationwide, urban/rural)**



ACCESS TO ELECTRICITY

There is little difference in access to electricity between male- and female-headed households, except among households in rural electrified areas (Figure 61). Slightly more than one-fifth (21%) of female-headed households in rural areas are in Tier 0, compared with 16% of male-headed households (Figure 62).

FIGURE 61 • **Distribution of female- and male-headed households by source of electricity, (urban/rural)**

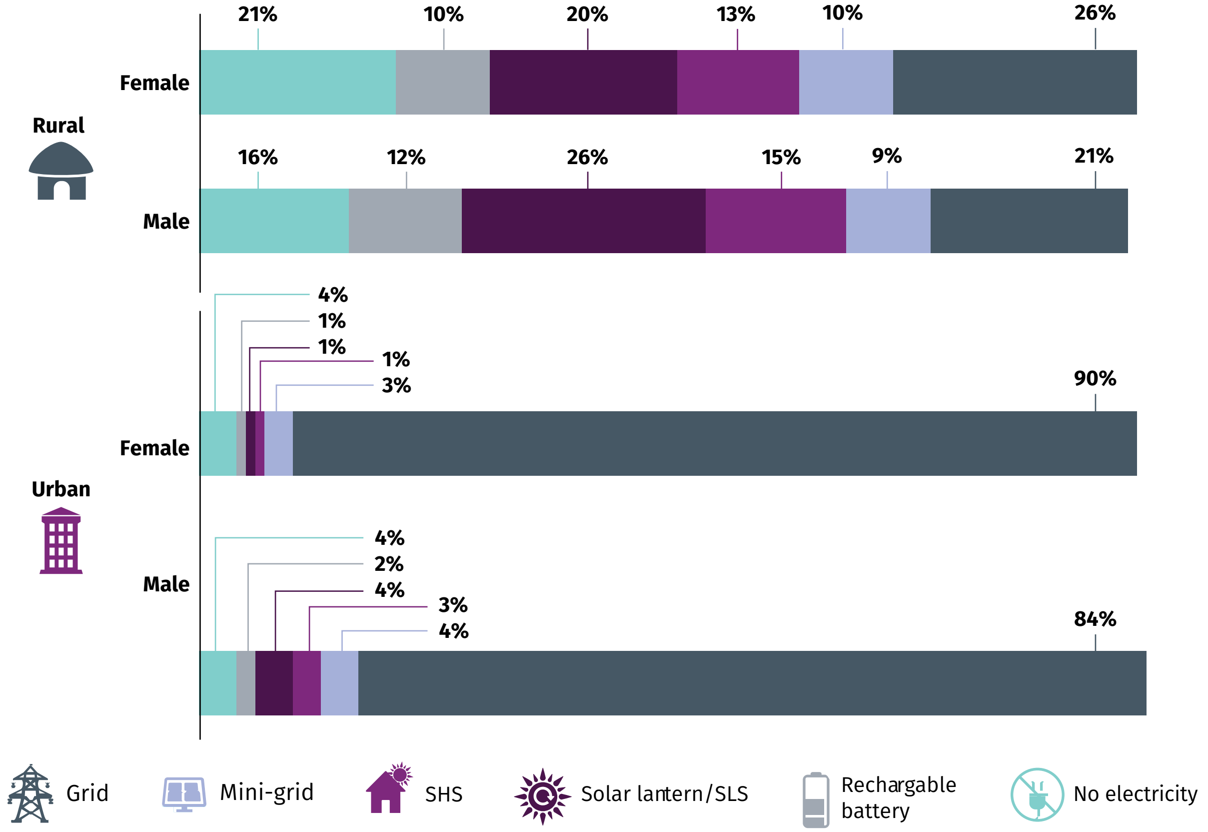
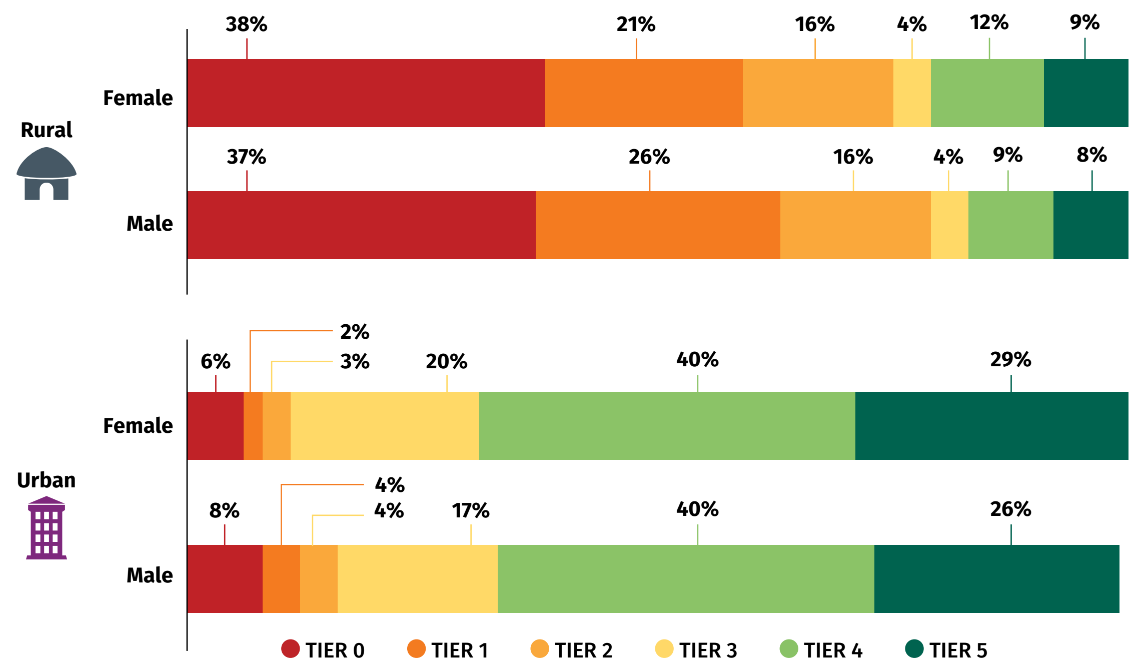
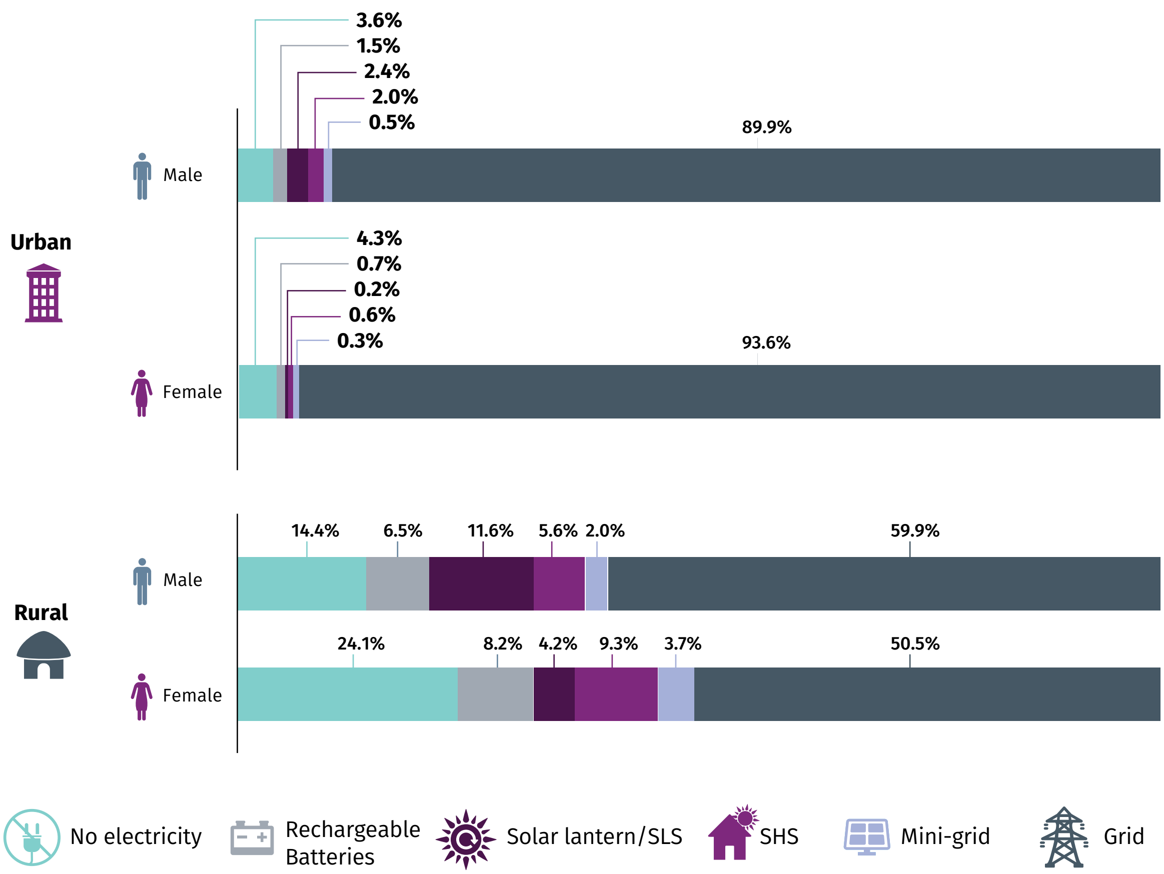


FIGURE 62 • **Distribution of female- and male-headed households based on MTF electricity tier (urban/rural)**



A comparison of the main sources of electricity across female- and male-headed households facing the same options in the choice of source of electricity was conducted in grid-electrified areas.[17] In rural villages that are on the grid, a larger share of female-headed households (24.1%) have no electricity relative to male-headed households (14.4%) (Figure 63).[18] Where data are available on grid connections and off-grid solutions, male-headed households are more likely to adopt either the grid or off-grid solution relative to female-headed households. The grid take-up rate is similar between male-headed and female-headed households in urban electrified areas. This pattern reflects the distribution of expenditure quintiles among these households because the spending gap between male- and female-headed households is larger in rural areas.

FIGURE 63 • **Distribution of female- and male-headed households by main source of electricity in electrified areas (urban/rural)**



Female-headed households were less willing to pay for off-grid solar solutions. According to the WTP for an SHS, female-headed households appeared to be less willing to pay for an SHS than male-headed households (Figure 64). This response may be attributed to the ability to pay because of the difference in wealth. Furthermore, female-headed households are more likely to be in grid-electrified villages.[19]

17 In this report, a grid-electrified village is any village that includes at least one household with a grid connection.

18 A similar comparison in non–grid-electrified areas has not been undertaken because the sample size is insufficient for such an analysis.

19 In rural areas, 51.9% of female-headed households are in grid-electrified villages. Among male-headed households in the same areas, the share is 35.4%.

Households in grid-electrified villages would thus be less willing to pay for SHSs. The tendency is more mixed, but the female-headed households are less willing to pay for a grid connection (Figure 65).

FIGURE 64 • **WTP for a solar home system, by gender of the head of household**

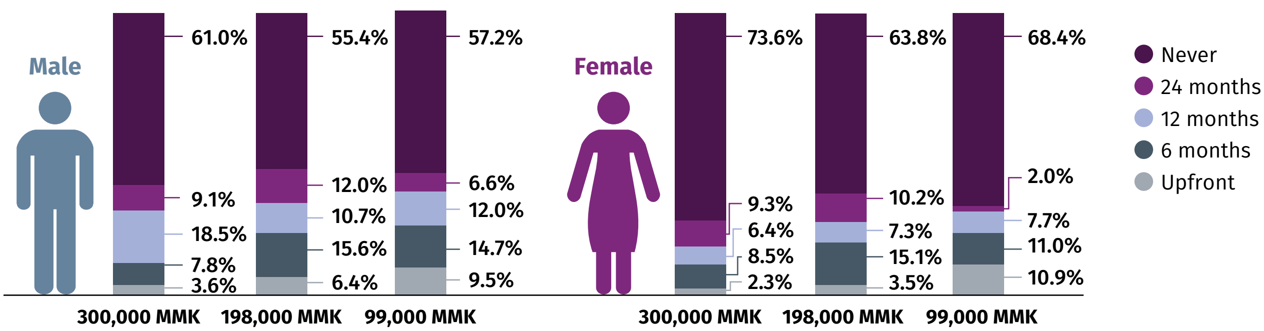
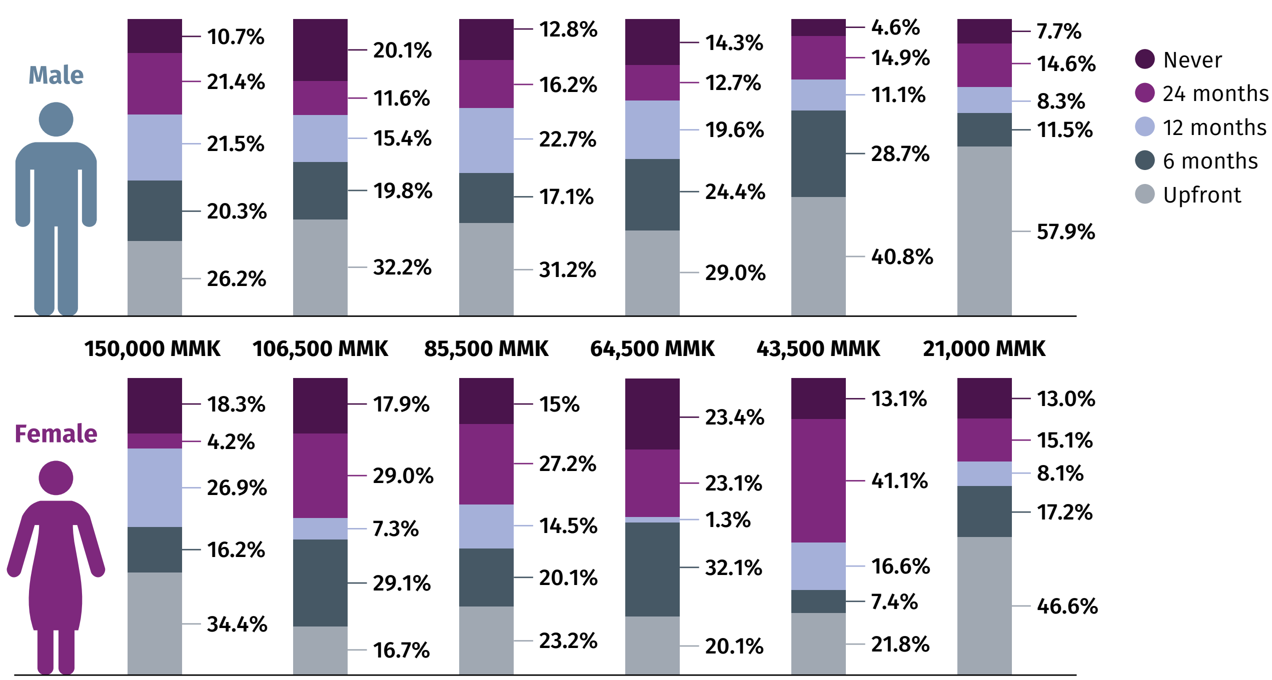


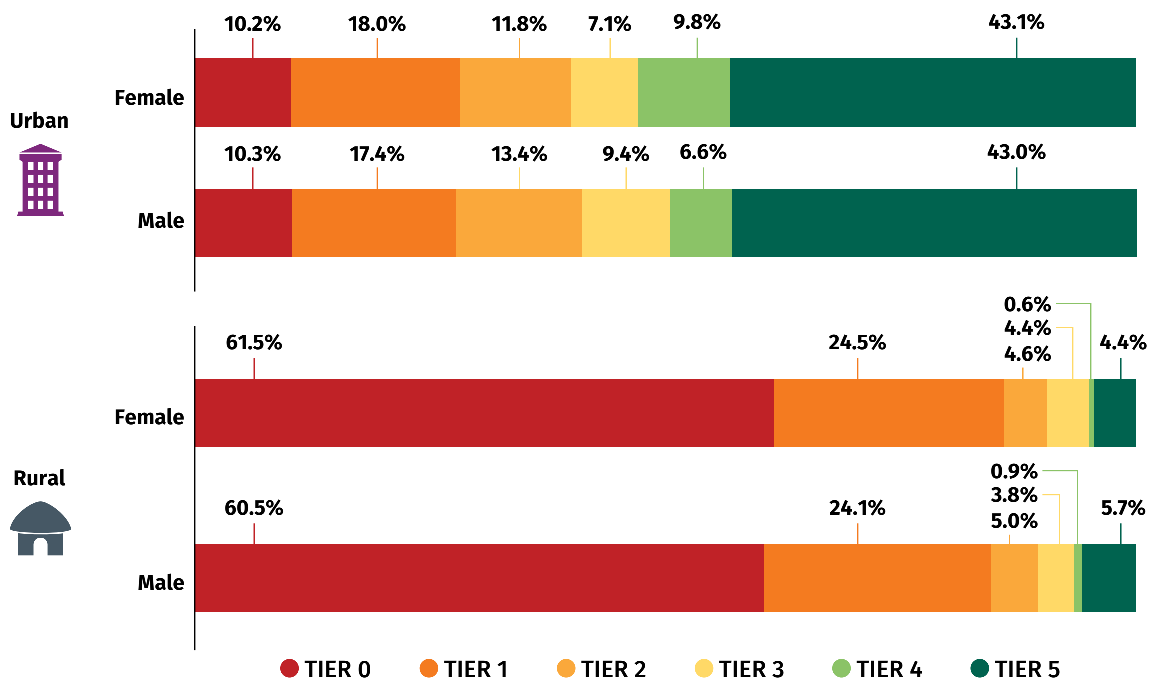
FIGURE 65 • **WTP for a grid connection, by gender of the head of household**



ACCESS TO MODERN ENERGY COOKING SOLUTIONS

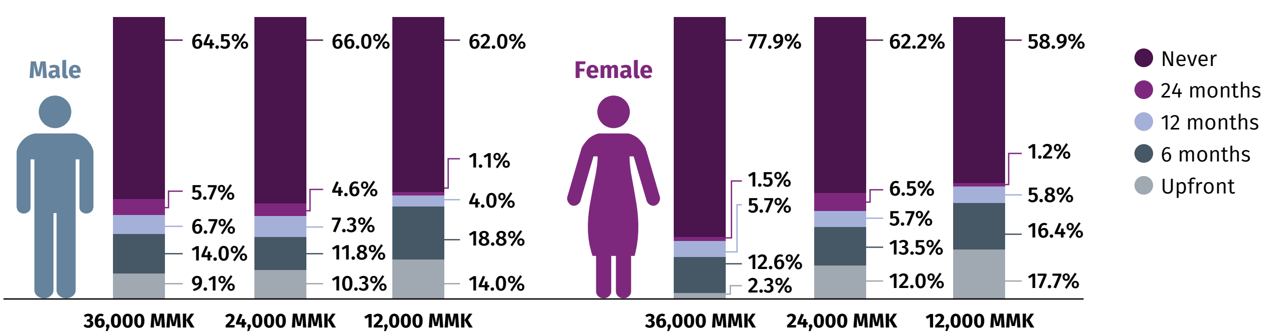
No significant distinction is observed in the distribution of the cooking tier between male- and female -headed households in urban and rural areas. In urban areas, because more households use either an electric or an LPG stove as the primary cookstove, 43.0% and 43.1% of male- and female-headed households are in Tier 5, respectively. In rural areas, more than half of both male- and female-headed households are in Tier 0, mainly because of the use of three-stones or traditional stoves, which are in stove emission Tier 0 (Figure 66).

FIGURE 66 • **Distribution of female- and male-headed households based on MTF cooking tier (urban/rural)**



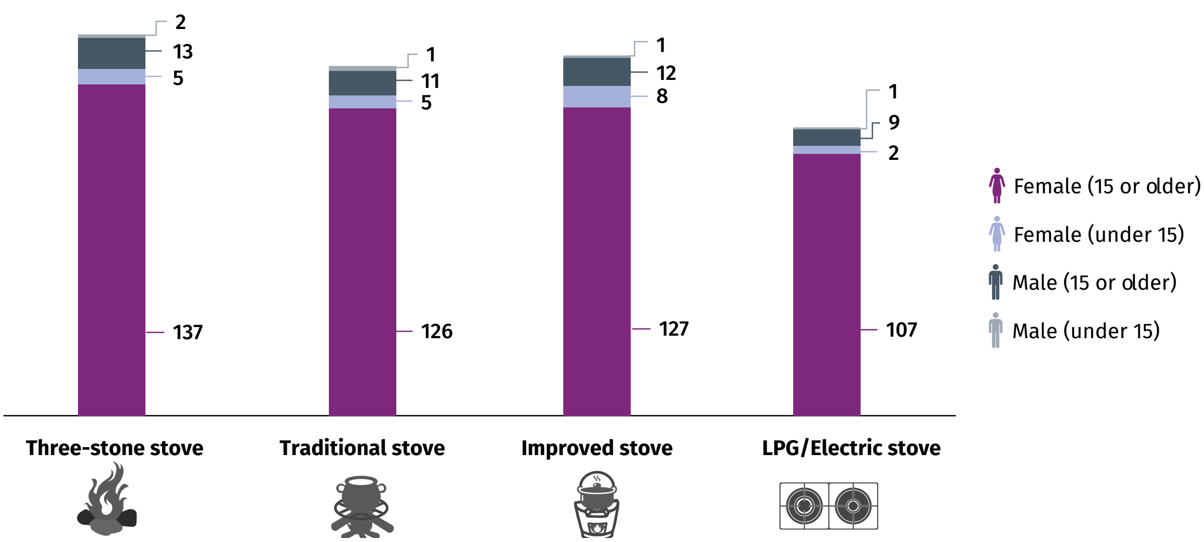
Regardless of the gender of the household head, more than half the households currently using three-stone stoves or traditional stoves were not willing to pay for an ICS. Offering payment over a designated time period may potentially help increase the adoption of an ICS by households. Given the full-price option (36,000 MMK or 26 USD) on an ICS, more female-headed households were not willing to pay (77.9%), which is%notably higher than the corresponding share among male-headed households (64.5%) (Figure 67). However, given the option of paying less, the response showed that the gap in the level of interest between male- and female-headed households became narrower.

FIGURE 67 • **WTP for an improved cookstove, by gender of the head of household**



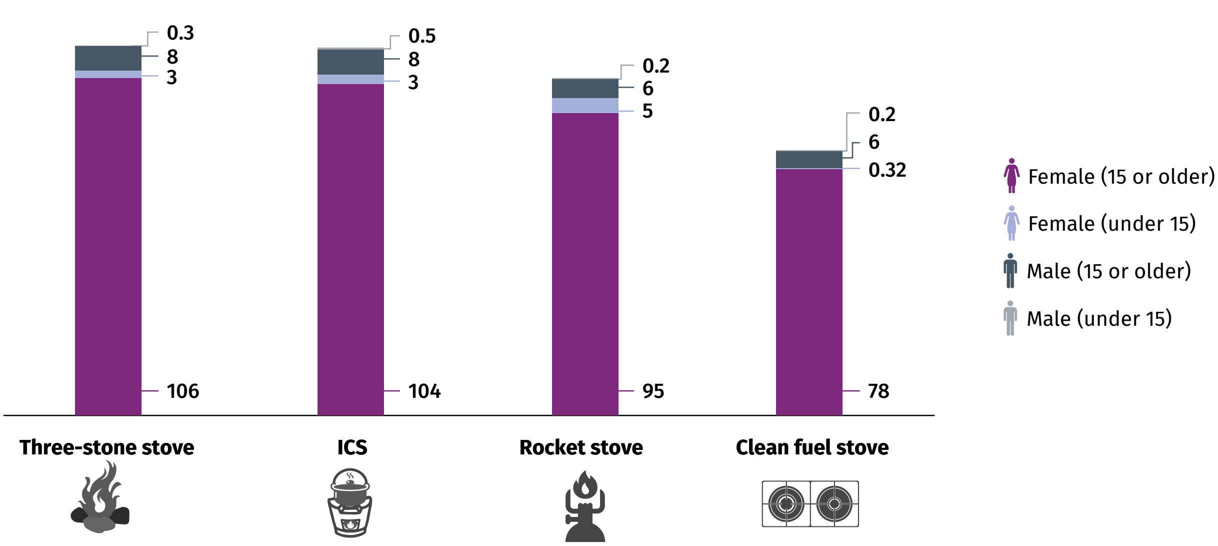
Female household members, particularly those aged over 15, spend more time cooking than their male counterparts. Adult women cooking with biomass stoves[20] spend more than 120 minutes per day in the cooking space, compared to the less than 15 minutes for adult men (Figure 68). As such, adult women are more highly affected by indoor air pollution, thus, would most benefit from improvements in the Cooking Exposure attribute.

FIGURE 68 • **Minutes spent in the cooking space per day, by primary stove type**



The use of more efficient cookstoves such as rocket stove or clean fuel stoves (LPG and electric stove) helps women save time in cooking. Depending on the stove design, women cooking with biomass stoves spend 95 to 106 minutes a day cooking, whereas women cooking with clean fuel stoves spend 77 minutes a day (Figure 69).

FIGURE 69 • **Average minutes spent on cooking per day, by primary stove type**



20 Biomass cookstove include three-stone stove, traditional stoves, and ICS.

ANNEX 1. MULTI-TIER FRAMEWORK

TABLE A.1.• The Multi-Tier Framework for Measuring Access to Electricity

ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Capacity (Power Capacity ratings)		<3W	3W-49W	50W-199W	200W-799W	800W-1999W	≥2kW
Availability	Day	<4 hrs	4-8 hrs		8-16 hrs	16-23 hrs	≥23 hrs
	Evening	<1 hrs	1-2 hrs	2-3 hrs	3-4 hrs	4 hrs	
Reliability	(Frequency of disruptions per week)	>14				4-14	≤3
	Duration of disruptions per week					≥ 2 hrs (if frequency is ≤3)	<2 hrs
Quality (Voltage problems affect the use of desired appliances)		Yes				No	
Affordability (Cost of a standard consumption package of 365kWh/year)		≥ 5% of household expenditure (income)			< 5% of household expenditure (income)		
Formality (Bill is paid to the utility, pre-paid card seller, oi authorized representative)		No				Yes	
Health and Safety (Having past accidents and perception of high risk in the future)		Yes				No	

Source: Bhatia and Angelou 2015
Note: Colors signify tier categorization

TABLE A.2 • The Multi-Tier Framework for Measuring Access to Modern Energy Cooking Solutions

ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Cooking Exposure	ISO'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 (mg/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: Bhatia and Angelou 2015; ISO 2018

Note: Colors signify tier categorization

ANNEX 2. SAMPLING STRATEGY

ISSUES ASSOCIATED WITH SAMPLE SIZE

The sample size proposed for Myanmar is designed to help produce sufficiently precise estimates of each tier nationwide and by urban and rural location. This section discusses the factors that should be taken into consideration in the determination of the appropriate sample size calculation and provides a justification for the proposed sample size. The major issues considered in determining the appropriate survey sample size are as follows:

1. The precision of the survey estimates (the sampling error)
2. The quality of the data collected by the survey (the nonsampling error)
3. The cost in time and money of data collection, processing, and dissemination

The following subsections discuss each of these issues in turn.

1. The precision of the survey estimates:

The precision of a sample survey estimate is crucial in determining the sample size. A sample taken from a population does not produce a complete picture of the population. However, an appropriately drawn random sample of reasonable size can provide a reasonably clear picture of the characteristics of that population, certainly sufficient for an examination of policy implications or for decision-making purposes. From a sample of households, one may collect data and generate a sample or survey estimate of a population parameter. The value of the population parameter of the characteristics of interest is generally unknown. Sampling errors or margins of error greatly depend on the size of the sample and much less on the size of the population. To maximize the sample size and to reduce the sampling error, the prevalence rate in this calculation is set at 50 %. The formula used to calculate the sample size is as follows:

$$n = \frac{z^2 r(1-r) fk}{e^2} = \frac{z^2 r(1-r)[1+\rho(m-1)]k}{e^2} \qquad \text{(B.1)}$$

Where:

n = the sample size to be determined.

z = the z-statistics corresponding to the confidence level. A widely used confidence level is 95 %, for which z = 1.96.

r = the estimate of the indicator of interest (50%).

f = a sample design effect, which represents how much larger the squared standard error of a two-stage sample is relative to the squared standard error of a simple random sample of the same size. The default value of f for infrastructure interventions is 2.0 or higher, which should be used unless there is supporting empirical data from similar surveys that suggest a different value. The sample design effect has been included in the sample size calculation formula (B.1) and is defined as $f = 1 + \rho\ (m - 1)$.

ρ = the intracluster correlation coefficient, which is a number that measures the tendency of households within the same primary sampling unit (PSU) to behave alike in regard to the variable of interest. ρ is almost always positive and normally ranges from 0 (no intracluster correlation) to 1 (if all households in the same PSU are exactly alike). For many variables of interest in the Living Standards Measurement Study surveys, ρ ranges from 0.01 to 0.10, but it can be 0.5 or larger for infrastructure-related variables.

m = the Average number of households selected per PSU.

k = factor accounting for nonresponse. Households are not selected using replacement. The final number of households interviewed will thus be slightly less than the original sample of households eligible for interview. The sample size should be calculated to reflect the experience in the country in question. For most developing countries, the nonresponse rate is typically 10 % or less. So, a value of 1.1 (= 1 + 10 %) for k would be conservative.

e = margin of error or level of precision; in this report, the margin of error applied in the calculation varies from 1.0 % to 5.5 %.

2. The quality of the data (nonsampling error)

Besides sampling errors, the data in a household survey are vulnerable to other inaccuracies for reasons as diverse as refusals, respondent fatigue, measurement errors, interviewer errors, or the lack of an adequate sample frame. These are collectively known as nonsampling errors. Nonsampling errors are more difficult to predict and quantify than sampling errors, but good planning, management, and the supervision of field operations are well accepted as the most effective ways to keep these errors under control. Moreover, it is likely that management and supervision will be more difficult with larger samples than with smaller ones. Thus, one would expect nonsampling errors to increase with sample size. Limiting the sample size to less than 5,000 respondents is therefore a goal.

3. The cost of data collection, processing, and dissemination.

The sample size can affect the cost of the survey implementation dramatically. It will also affect the time in which the data can be collected, processed, and made available for analysis. The availability of the survey firm and the cost in each country would affect the total cost of survey implementation, too. Thus, the cost of data collection, processing, and dissemination should be considered in determining the sample size in each country.

SAMPLE SIZE CALCULATION AND DISTRIBUTION

The purpose of the MTF survey is to identify and analyze energy access tiers (Tiers 0 to 5) in urban and rural areas as well as nationwide. Because the concept of the MTF has been introduced recently, and the aim of this global survey is to establish the baseline for monitoring energy access globally, the indicator of interest (r) is unknown. The sample size for each country is thus calculated using the prevalence rate of 50 % to maximize the sample size and reduce the margin of error. (Standard errors are inversely proportional to the square root of the sample size: $e = z^*\sigma/\sqrt{n}$.) Because the nonresponse rate is typically under 10 % in developing countries, a value of 1.1 for k (the nonresponse rate) would therefore be a conservative choice (United Nations 2003, 2011). The number of households selected per PSU is 11. However, this number may be modified depending on the level of homogeneity in a given PSU and community. Because of the characteristics of infrastructure variables and indicator, 0.5 is selected for the intracluster relation coefficient (ρ); so, the design effect (f) in the calculation will be equal to 6 (Grosh and Muñoz 1996).

The number of analytic domains has a large impact on the sample size and strategy, too. Analytic domains may be defined as the analytic subgroups for which equally reliable data are required for the analysis. An important implication of the equal reliability requirement for domains is that disproportionate sampling rates must be used. Thus, if the population ratio between urban and rural areas is not 50 : 50, oversampling of the urban sector or the rural sector will most likely be necessary in most countries to achieve equal sample sizes and thereby realize equal reliability. Tables B.1 and B.2 show two ways to calculate the sample size. The use of only one domain involves calculating the sample size using the distribution between urban and rural areas as 50 : 50 (Table B.1), while the other is based on two domains and involves allocating a sample size that is proportional to the urban and rural population (Table B.2). There are two implications of the deliberate oversampling of subgroups, whether domains or strata. First, deliberate oversampling necessitates the use of compensating survey weights to form the national estimates. Second and more importantly, the national estimates are somewhat less reliable than they would be if the sample were distributed proportionately among the subgroups. Hence, the latter implication is a distinct limitation as well because of the negative effect of oversampling on the national estimates.

TABLE B.1 • **Calculation Based on One Analytic Domain**

Before oversampling

Sample size			Margin of error, %		
National	Urban	Rural	National	Urban	Rural
3130	926	2203	4.5	8.3	5.4
2535	750	1784	5.0	9.2	6.0
2095	619	1475	5.5	10.1	6.6

TABLE B.2 • **Calculation Based on Two Analytic Domain**

Before oversampling

Sample size			Margin of error, %		
National	Urban	Rural	National	Urban	Rural
3520	1760	1760	4.2	6.0	6.0
3000	1500	1500	4.6	6.5	6.5
2586	1293	1293	5.0	7.0	7.0

For the purpose of the MTF global survey, it is important to ensure that there are sufficient households in (1) urban areas and rural areas and (2) each tier (Tiers 0–5) in the population so that more reliable estimates can be reported on these subgroups. To accomplish this, members of the subgroup are oversampled by selecting more people from this group than is the case if everyone in the sample had an equal chance of being selected. Unlike the urban and rural subgroups, there are no existing historical data on the MTF tiers. The electrification rate and the nonsolid cooking fuel access rate in urban and rural are therefore used as a proxy to see if a sufficient number of households may thereby be selected for the gap analysis and other disaggregated analysis. This analysis will help policy makers identify current energy gaps and design solutions. If a country has a high level of electrification (nonsolid fuel access), this indicates that there will be a lower probability of selecting households belonging to lower tiers, such as Tier 0 or Tier 1, and vice versa. As shown in Table B.3, 78.91 % of households are connected to electricity in urban areas, while this rate decreases to 26.4 % in rural areas. Meanwhile, only 6.07 % of rural households have access to nonsolid fuel (Table B.4).

TABLE B.3 • **Electrification Rate (Urban/rural, %)**

Energy	Urban	Rural
Electrified	78.9	26.4
Nonelectrified	21.0	73.6
Total	100	100

TABLE B.4 • **Nonsolid Fuel Access Rate (Urban/rural, %)**

Fuel	Urban	Rural
Nonsolid fuel	46.1	6.07
Solid fuel	53.8	93.9
Total	100	100

Thus, more administrative units or PSUs are selected at a higher electrification rate (nonsolid fuel access rate) in the first stage of sampling if the electrification rate (nonsolid fuel access rate) is too low (below 20 %). This also applies in the opposite case. If the electrification rate (nonsolid fuel access rate) is too high (above 80 %), more administrative units or PSUs with lower access rates (nonsolid fuel access rates) are oversampled. Although the number of PSUs increases, the number of households selected per PSU will be fixed. Thus, the k-means clustering methodology was employed to select the states and regions that will be oversampled. In urban areas, urban states and regions where electrification and nonsolid fuel access rates are low need to be oversampled: the urban areas of Chin, Kachin, and Rakhine states and Tanintharyi Region. In rural areas, states and regions with a higher access rate in electricity and nonsolid cooking fuel need to be oversampled: the rural areas of Kayah and Mon states, Nay Pyi Taw Territory, and Yangon Region. The sample size of these states and regions are doubled, and the states are oversampled by 20 %.

If a better proxy is found for predicting the tier of households more precisely, then the former proxy will be replaced, and the calculation will be run again. Why oversample? Oversampling is carried out because, given that the margin of sampling error is related to the size of the sample, increasing the sample size for a particular subgroup through the use of oversampling allows estimates that are associated with a smaller margin of error. A survey that includes an oversample weights the results so that members in the oversampled groups are weighted to their actual proportion in the population; this allows the overall survey results to represent both the national population and the oversampled subgroup. Tables B.5 and B.6 report the results of the calculation.

TABLE B.5 • Calculation Based on One Analytic Domain

After oversampling

Sample size			Margin of error, %		
National	Urban	Rural	National	Urban	Rural
3366	1034	2332	4.34	7.83	5.21
2750	825	1925	4.80	8.77	5.74
2321	737	1584	5.23	9.27	6.33

TABLE B.6 • Calculation Based on Two Analytic Domains

After oversampling

Sample size			Margin of error, %		
National	Urban	Rural	National	Urban	Rural
3718	1859	1859	4.13	5.84	5.84
3201	1595	1606	4.45	6.30	6.28
2772	1386	1386	4.78	6.76	6.76

The sample size presented in Tables B.5 and B.6 is a range of numbers suggested by a group of sample components with margins of error ranging from 4.1 % to 5.2 % at the national level. It is suggested that the sample size be able to provide nationally representative data at a margin of error between 4.5 % and 5.5 % and urban and rural representative data at a margin of error between 5.2 % and 9.3 %. After having chosen 4.5 % ≤e ≤5.5 %, these numbers are rounded to obtain the final sample size. Other factors also need to be absorbed, including nonsampling errors, the cost of survey activity in each country, and local factors, to finalize the sample size. Then, the sample size is allocated to each state proportional to the state population.

Stratification

Strata are subsets of the population within each of which a separate sample is selected. Stratification is usually carried out either to seek to improve the overall precision of the estimates by attaining control over the sample composition or to produce estimates for subgroups of the population that otherwise might be underrepresented in the sample. In addition, survey implementation can benefit from the stratified strategy. The stratification isolates the geographical locations in which the survey operations, including the listing of households and the administering of interviews, will be conducted. The stratification will thus limit the size of the administrative unit where the household list is required.

The main focus of the MTF global survey in Myanmar is to assess the quality of energy service for each tier in urban and rural areas as well as nationwide. A stratified two-stage sample design was used for the MTF global survey, with 15 strata, which are regions, states, and territories in the country (Table B.7).[21] The first-stage unit is the urban ward and the rural village tract. The household as the last-stage unit. Because some wards and village tracts are quite large in terms of the number of households in urban areas and land size in rural areas, it would have been difficult logistically to interview the 11 households selected randomly within each ward and village tract. Thus, for each selected ward or village tract, a frame consisting of the list of all streets or villages needs to be built prior to data collection activities. With the predetermined path in the community on the sketch map and the sampling interval calculated using the total number of households and the fixed sample size, a unique systematic

21 The regions are Ayeyarwady, Bago, Magway, Mandalay, Sagaing, Tanintharyi, and Yangon. The states are Chin, Kachin, Kayah, Kayin, Mon, Rakhine, and Shan. The territory is Nay Pyi Taw.

sample could then be drawn conforming to the random selection with a known selection probability. Within each primary sampling unit, a sample of 11 households is selected.

TABLE B.7 • **Local Administrative Units, Myanmar**

State/Region/Territory	District	Township
15	74	413

Source: Calculated from the 2014 census and Integrated Household Living Conditions Survey 2009–10.

ANNEX 3. COOKSTOVE TYPOLOGY

Typology	Picture
Three-stone stove • Open fire • Fuel rests on the ground	 
Traditional biomass stove • Enclosed combustion chamber • Pot placed above the fire • Fuel rests on the ground	 
Improved biomass stove • The combustion chamber is well insulated • Fuel rests on a shelf	 
Clean fuel stove • LPG, electric stoves	 

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