NIGER

Beyond Connections

Energy Access Diagnostic Report
Based on the Multi-Tier Framework

ESMAP

WORLD BANK GROUP

MTF Multi-Tier FRAMEWORK

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Marina Brutinel, Farouk Nabourema, Niki Angelou, Bryan Bonsuk Koo, Elisa Portale and Dana Rysankova

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

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ABBREVIATIONS

CFAF	CFA francs (Currency)*
CFL	compact fluorescent lamp
EA	enumeration area
ESMAP	Energy Sector Management Assistance Program
ICS	improved cookstove
kW	kilowatt
kWh	kilowatt-hour
LED	light-emitting diode
LPG	liquefied petroleum gas
MTF	Multi-Tier Framework
RISE	Regulatory Indicators for Sustainable Energy
SHS	solar home system
SLS	solar lighting system
W	watt
WHO	World Health Organization
WTP	willingness to pay

*Average exchange rate, February 2, 2018, was US$1 = CFAF 524.35.

EXECUTIVE SUMMARY

Niger is a vast, landlocked, and mostly arid Sub-Saharan country, located in the heart of the Sahel region, with a rapidly growing population, estimated at 22.4 million (World Bank 2018a), of which the majority lives in rural areas. Despite considerable progress in the area of poverty reduction, extreme poverty remains very high, at an estimated 41.5% in 2019, affecting more than 9 million people in a country prone to climate risk and insecurity.

The World Bank, with support from the Energy Sector Management Assistance Program (ESMAP), has launched the Global Survey on Energy Access, using the Multi-Tier Framework (MTF) approach. 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, "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 wide differences in user experience.[1]

ACCESS TO ELECTRICITY

The MTF defines access to electricity according to a spectrum that ranges from Tier 0 (no access) to Tier 5 (full access) through seven attributes: Capacity, Availability, Reliability, Quality, Affordability, Formality, and Health and Safety.[2] The final aggregate tier for a given household is based on the lowest tier that that household attained among all the attributes.

- **Source of electricity:** The MTF survey data show that, as of 2018, 19.5% of Niger households have access to electricity through either the national grid or off-grid sources, while the remaining 80.5% have no access to electricity. Four out of five households with access to a source of electricity are connected to the national grid (15.8%), and the remaining 3.7% primarily use solar off-grid solutions. A severe gap exists in access to electricity between urban and rural areas: close to half of urban households (45.4%) access electricity through the national grid, while 7.3% of rural households do.

- **MTF aggregate tier for access to electricity:** The MTF defines Tier 1 or above as having access to electricity based on Sustainable Development Goal (SDG) indicator 7.1.1. Nationwide, 17.5% of Niger households are in Tier 1 or above for electricity access. Specifically, 48.8% of urban households and 8.5% of rural households are in Tier 1 or above. Grid users are mainly concentrated in Tiers 3 through 5, while the very few users of off-grid solutions are primarily in Tiers 0 through 2.

- **Households in Tier 0:** Nationwide, 82.5% of households are in Tier 0 for access to electricity, and virtually all of them do not have any source of electricity. For households without any source of electricity, it will be critical to provide either a grid connection or an off-grid energy solution. A major barrier preventing households from gaining a grid connection is the up-front cost. More flexible payment plan options or access to financing, such as subsidies, could help in addressing the burden of paying high up-front costs, while other direct costs associated with gaining a connection, such as internal wiring, should be examined. Mini-grid development could be considered in areas not

[1] The MTF access rate includes access provided by off-grid technologies, which is often excluded by the binary rate, but excludes connections that do not meet its criteria for minimum level of service.
[2] For descriptions of the MTF and its attributes, see Annex 1.

covered by the grid, where sizeable electricity demand exists. Off-grid solar products could help households in other villages not yet reached by the grid infrastructure. Expanding access to such solutions relies on both developing the market for solar products in Niger (by expanding product offerings and also initiating a consumer awareness program) as well as addressing affordability issues through payment plans.

- **Grid-connected households:** Grid-connected households are mostly in higher tiers: four out of five grid-connected households (79.6%) are in Tier 3 or above, with 31.1% being in the highest tier, Tier 5. Challenges related to Availability, Reliability, and Affordability are the main ones preventing grid-connected households from being in the highest tier.

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

The MTF measures access to modern energy cooking solutions along a spectrum ranging from Tier 0 (no access) to Tier 5 (full access) through six attributes: Cooking Exposure, Cookstove Efficiency, Convenience, Safety of the Primary Cookstove, Affordability, Feul availability.[3] The final aggregate tier for a household is based on the lowest tier that the household attained among all the attributes.

- **Primary cookstove and fuel:** Niger households reported using one of four types of cookstoves as their main cookstove: 86.8% of households use a three-stone stove,[4] 7.1% use a traditional stove, 4.6% use a liquefied petroleum gas (LPG) stove, and the remaining 1.5% use an improved cookstove. Rural and urban households rely on different cooking technologies. While virtually all rural households cook on three-stone stoves (95.1%), this share, among urban households, drops to more than half (58.1%). Beyond this, urban households rely to an almost equal degree on LPG stoves (19.9%) and traditional cookstoves (19.2%). LPG penetration is essentially an urban phenomenon (such stoves are used by only 0.3% of households in rural areas). The share of households who practice stove stacking is negligible.

- **MTF aggregate tier for access to modern energy cooking solutions:** The majority of households are concentrated in Tiers 0 and 1 (21.2% and 74.1%, respectively). Households in Tiers 0 and 1 for access to cooking solutions mostly use biomass fuels[5]. Most rural households are in Tier 0 and 1 while 20.2% of urban households are in Tiers 2 to 5 with 8.6% reaching the top tier. Clean fuel stove users tend to be in higher tiers for access to modern energy cooking solutions.

- **The main constraint for 94.4% of households in Tiers 0 and 1 is Cooking Exposure (as indicated by their use of three-stone stoves as primary stoves)**. Since no improved cookstoves are currently on the market in Niger, a possible solution is to introduce adequate cookstoves for firewood (used as a primary fuel by 87.5% of Niger households) based on an assessment of households' needs, preferences, and willingness to pay—and the promotion of the stoves' use through awareness-raising campaigns.

- **The promotion of clean fuel stoves is the ultimate goal in improving access to modern cooking solutions,** especially for those who can more readily afford and acquire them, notably in urban areas. It is recommended that the potential for increasing the adoption of LPG stoves be analyzed,

[3] For descriptions of the MTF and its attributes, see Annex 1.
[4] 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.
[5] Biomass fuels used in Niger are firewood (collected or bought), charcoal, animal waste/dung, crop residue/plant biomass

and a comprehensive and systematic plan be devised that covers both the supply and demand side, including awareness-raising campaigns.

- **For the significant share (81.6%) of households lacking both access to the grid and access to an improved cookstove for cooking with biomass, synergies can be found** by providing public support to distributors that can deliver both solar products and improved cookstoves to this segment, improving access to electricity as well as access to modern cooking solutions while reducing the cost of serving these households.

GENDER ANALYSIS

Nationwide, 7.8% of Niger households are headed by women. Female-headed households account for 10% of urban households and 7.2% of rural households. Over half of the women who head these households are widows.

Female heads of households are on average older than male heads, less likely to have attended school, and less likely to have a job. Female-headed households tend to be poorer than male-headed households: 35.8% of female-headed households are in the bottom expenditure quintile compared with 18.7% of male-headed households. They are also less likely to have access to finance than male heads (73.5% versus 78.6%, respectively).

Female-headed households are slightly less likely to have access to electricity than male-headed households (16.5% versus 19.8%). In urban areas, female-headed households are less likely to have access to grid electricity than are male-headed households (38.2% versus 46.1%), and in both rural and urban areas, their access to off-grid solutions is also lower. This translates into a marginally better performance in terms of the tier ranking for male-headed households: 9% of them are in Tiers 4–5, compared with 7.6% of female-headed households.

Female-headed households are slightly more likely to use three-stone stoves and less likely to use traditional stoves compared to male-headed households, while there is no gender gap in the use of LPG stoves. In terms of access to modern energy cooking solutions, the distribution of tiers under the MTF shows fairly small gaps between female- and male-headed households overall.

In Niger, women aged 15 and older spend considerably more time cooking or in the cooking area (more than 2 hours per day) than men, girls, or boys. Women are thus much more likely to be affected by indoor air pollution and to benefit from the use of cleaner cooking solutions.

MEASURING ENERGY ACCESS IN NIGER

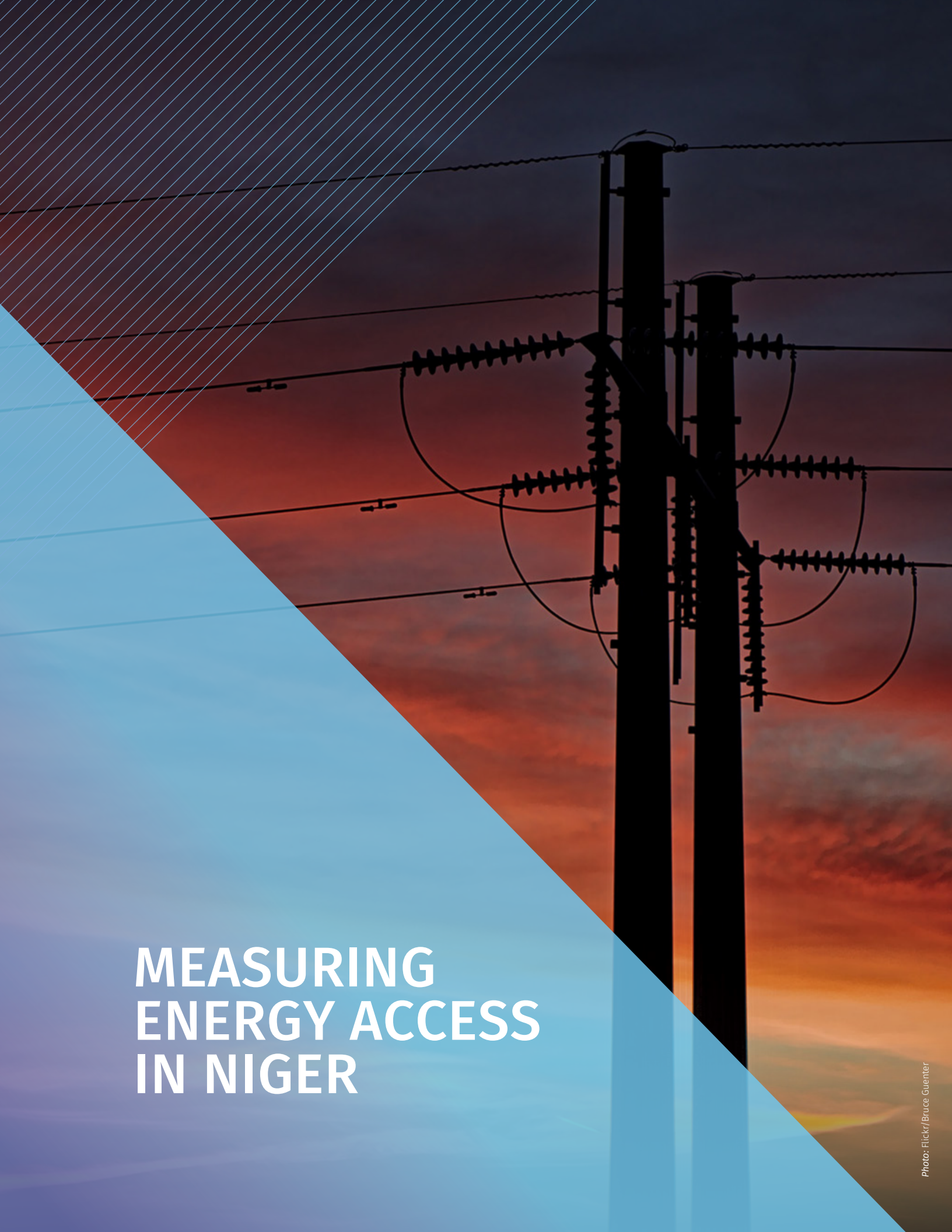


Photo: Flickr/Bruce Guenter

At the nexus of critical development challenges in Niger lies access to energy. Energy deeply influences human development and is an engine for economic growth and social development.

The importance and wide-ranging impact of energy access is recognized by the United Nations under Sustainable Development Goal (SDG) target 7.1, which seeks universal access to affordable, reliable, and modern energy services. SDG7 is crucial to achieving many other SDG targets as well—from poverty eradication via advancements in health, education, water supply, and industrialization to mitigating climate change.[6] The Government of Niger has been committed to achieving SDG 7 to benefit its people, and has thus collaborated with the World Bank to conduct the Multi-Tier Framework (MTF) survey to obtain guidance on setting targets, policies, and investment strategies for enhancing energy access.

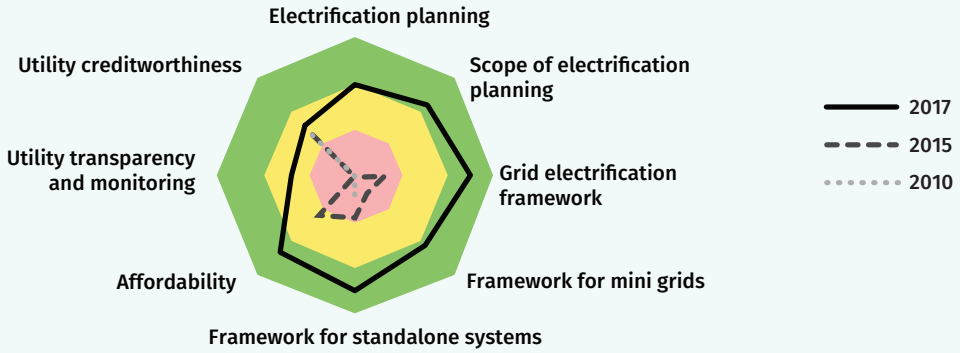
Also working toward this objective is the Sustainable Energy for All (SEforALL) initiative, launched by the Secretary-General of the United Nations, which sets universal access to modern energy as one of its three energy-access goals to be met by 2030.

BOX 1 • SUMMARY OF RISE ENERGY ACCESS INDICATOR FOR NIGER

Niger has instituted a moderately developed policy framework for electrification as of 2018, with marked improvements since 2010. The country saw major policy advances between years 2015 and 2017, when it developed electrification plans as well as frameworks for grid electrification, mini-grids, and stand-alone systems. The National Policy and Strategy for Electricity Access to a 2035 horizon was officially approved in 2018 as the country's first electrification plan. The plan was developed based on geospatial mapping, which includes a time frame for planned grid extension as well as for mini-grids. It also includes off-grid development and specifically targets female-headed households. Active policies are in place to bolster the development of off-grid solar systems. For example, Niger works with Lighting Africa to exempt taxes on the import of solar and other renewable energy products and their components (the exemption went into effect in September 2017). On the other end of Niger's electricity sector, its utilities have started improving their transparency, monitoring, and creditworthiness levels since 2018. The latest tariff revisions in 2018, which included a social tariff, are great strides toward making electricity access affordable and have benefited 42% of the utilities' customers across the nation.

[6] https://unstats.un.org/sdgs/report/2016/goal-07/.

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



Source: World Bank 2018b.

COUNTRY CONTEXT

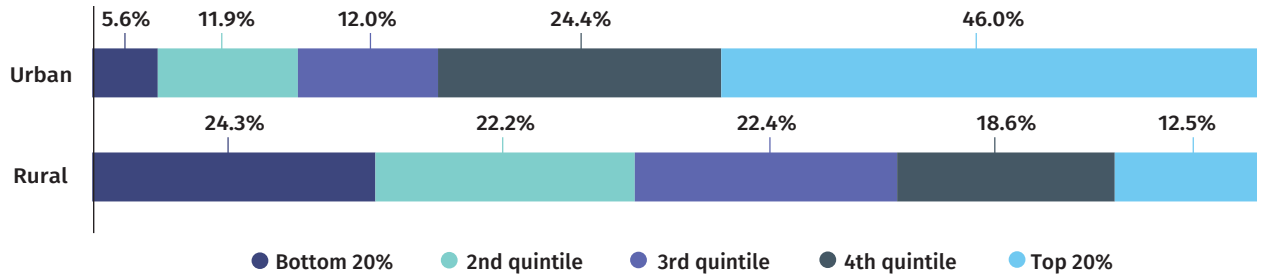
Niger is a vast, landlocked, and mostly arid Sub-Saharan country, located in the heart of the Sahel region, with a rapidly growing population, estimated at 22.4 million (World Bank 2018a), of which the majority lives in rural areas.

The Nigerien economy is not well diversified and depends primarily on agriculture, which represents 40% of its gross domestic product.

Economic growth increased from 4.9% to 6.5% between 2017 and 2018, surpassing the estimated potential growth rate of 4.8%. This increase was due primarily to the sound performance of the agricultural sector and sustained activity in the construction and services sectors. The medium-term economic outlook is positive: as of 2018, growth was projected to reach an average of 6% between 2019 and 2021, which is expected to reduce poverty by 1.5%. Major projects in the agriculture, energy, and services sectors, as well as the construction of a crude oil pipeline, will support this growth. Downside risks include fluctuations in the prices of basic goods, climate shocks, and insecurity.[7]

Over the past decade, Niger has made considerable progress in the area of poverty reduction. However, extreme poverty remains very high, at an estimated 41.5% in 2019, affecting more than 9 million people. Rural households are overrepresented in the bottom expenditure quintile (Figure 2).

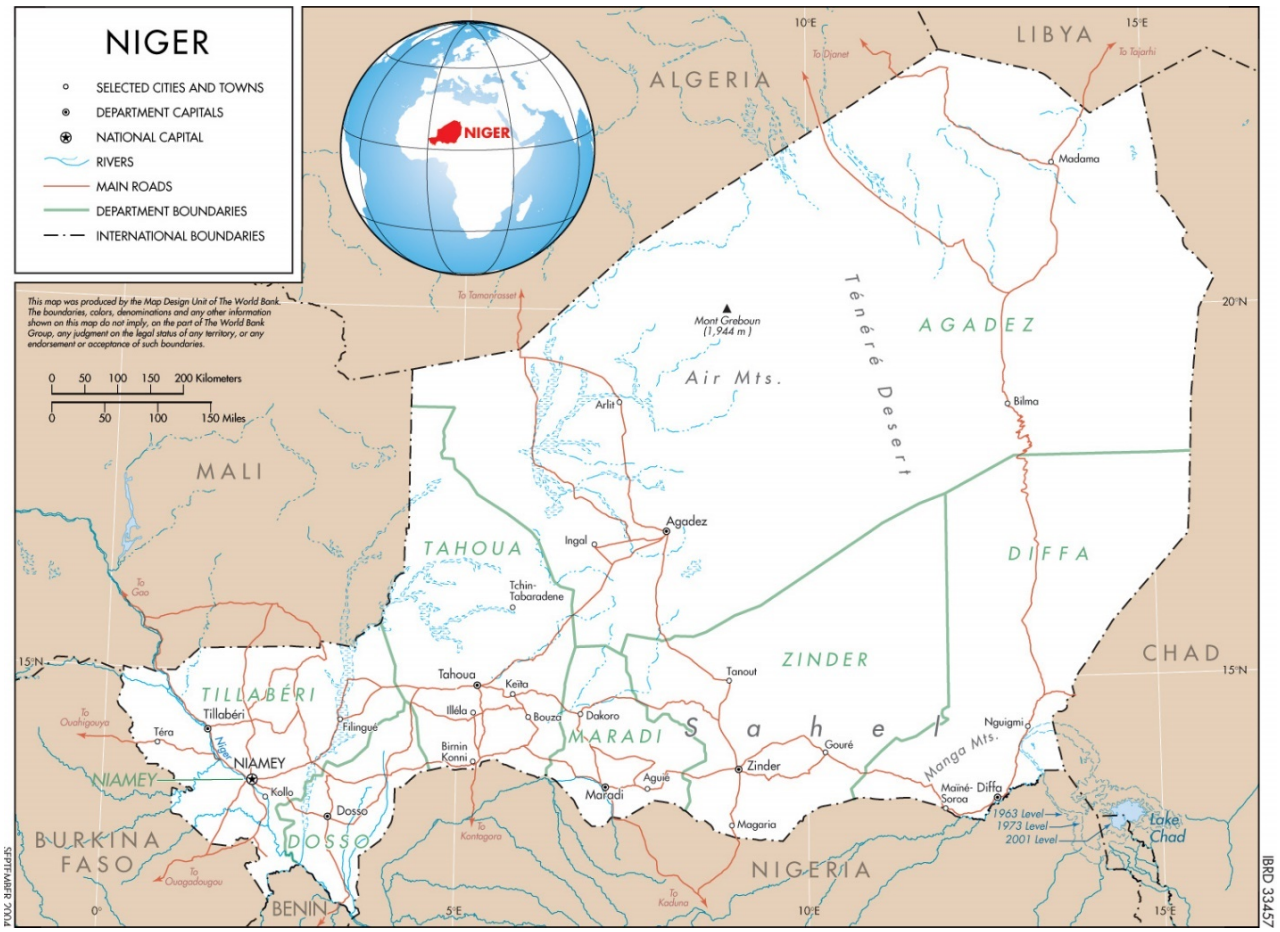
FIGURE 2 • **Distribution of expenditure quintiles (urban/rural)**



[7] All data collection and analysis were conducted prior to the global coronavirus pandemic (COVID-19). It is expected that the pandemic will strain Niger's economy, owing mainly to increased spending on health and social assistance services for vulnerable households to mitigate the impact of COVID-19. The pandemic will also have an adverse impact on international trade and foreign direct investment channels.

For a number of years, Niger has become a host country to populations fleeing conflict. It currently harbors 246,000 refugees and 186,000 displaced persons, primarily in Diffa and Tillabéri, and more recently, in Maradi, which is further exacerbating the country's fragility. Security conditions have deteriorated in recent years, particularly in the areas bordering Nigeria, Burkina Faso, and Mali, where armed groups have established bases and carry out repeated attacks against security forces and civilians.

MAP 1 • **Map of Niger**



The percentage of Niger's population with access to electricity increased from 6% to 20% between 2000 and 2017. While this progress is notable, the electrification rate remains far below Sub-Saharan Africa's average, and is among the lowest in the region. Also, access is concentrated in urban areas; almost all rural areas remain without. And even in urban areas connected to a grid, low generation capacity means that consumers suffer from a typically unreliable and low-quality supply. Additionally, less than 5% of the population has access to clean fuels and technologies for cooking (IEA et al. 2019). Pollution from solid fuel stoves causes eye problems and respiratory diseases in addition to environmental harm.

The electricity system in Niger is small, fragmented, and dependent on imports from Nigeria. Niger's power system comprises (i) two grids that are interconnected with Nigeria, which sells electricity at low cost; (ii) one grid supplied by a coal plant operated by Sonichar (a private company); and (iii) a number of diesel-based isolated grids. Decentralized mini-grids operated by the national utility supply 82 centers with electricity service levels ranging from continuous power to a few hours of power per day, using small diesel generators at prohibitive costs.

Off-grid electricity access in Niger has been limited, based mostly on unsustainable delivery models. Most off-grid initiatives have focused on stand-alone solar PV systems that meet the lowest tiers of electricity service, providing up to 4 hours of electricity per day. So far, these have not included adequate measures (e.g., technicians, spare parts, and product quality guarantees) to build the technical and commercial capacity of markets, or a sustainable revenue stream to ensure the maintenance and renewal of systems. The Government of Niger has acted to improve the institutional and legal framework in the power sector, but further work is required, specifically for off-grid electrification.

GLOBAL SURVEY ON ENERGY ACCESS USING THE MULTI-TIER FRAMEWORK

The World Bank, with support from the Energy Sector Management Assistance Program (ESMAP), has launched the Global Survey on Energy Access, using the Multi-Tier Framework (MTF). The survey's objective is to provide more nuanced data on energy access, including access to electricity and cooking solutions. The first phase is being carried out in 16 countries across Africa, Asia, and Latin America. The MTF approach goes beyond the traditional binary measurement of energy access—for example, "having or not having" a connection to electricity, "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 wide differences in user experience.

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 those attributes, it then defines six tiers of access, ranging from Tier 0 (no access) to Tier 5 (full access) along a continuum of improvement. Each attribute is assessed separately, and the overall tier for a household's access to electricity is the lowest tier attained across the attributes (Bhatia and Angelou 2015).

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, Table A1.1). Tier 0 refers to households that receive electricity for less than 4 hours a day (or less than 1 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

Tier 0	Tier 1	Tier 2
Electricity is not available or is available less than 4 hours a day (or less than 1 hour per evening). Households cope by using candles, kerosene lamps, or battery-powered devices, such as flashlights and radios.	Electricity is available at least 4 hours a day, including at least 1 hour per evening, and the Capacity is sufficient to power task lighting and phone charging or a radio (see Table 1). Sources that can be used to meet these requirements include a solar lighting system (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 at least 4 hours a day, including at least 2 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 at least 8 hours a day, including at least 3 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 kWh 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 at least 16 hours a day, including at least 4 hours per evening, and Capacity is sufficient to power high-load appliances as needed during that time, such as a washing machine, iron, hair dryer, 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 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 light bulbs and the type of appliances or electricity services a household uses. This typology is used to assess the Capacity attribute and the related tier.

- **Solar lanterns** power a single light bulb and allow only part of the household to be classified in Tier 1 for the Capacity attribute. Under the Multi-Tier Framework (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 lighting systems (SLSs)** power two or more light bulbs and allow part of or the entire household to be classified in Tier 1 for Capacity.
- **Solar home systems (SHSs)** power two or more light bulbs and appliances such as televisions, irons, microwaves, or refrigerators. See Table 1 for the load level associated with each Capacity tier.

TABLE 1 • Appliances by load level and associated Capacity tiers

Load level (in watts, W)	Indicative electric appliances	Capacity tier typically needed to power the load
Very low load (3–49 W)	Incandescent light bulb, fluorescent tube, compact fluorescent lamp, light-emitting diodes (LEDs), torch/flashlight/lantern, radio/CD players/sound system, 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, VCD/DVD	TIER 2
Medium load (200–799 W)	Indoor air cooler, refrigerator, electric water pump, electric food processor/blender, rice cooker, freezer, electric sewing machine, electric hot water pot or kettle	TIER 3
High load (800–1,999 W)	Washing machine, electric iron, microwave oven, hair dryer	TIER 4
Very high load (2,000 W or more)	Air conditioner, space heater, electric water heater, solar-based water heater	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 be powered?"): The Capacity of the electricity supply (or peak capacity) is the ability of the system to provide a certain amount of electricity to operate various appliances, ranging from a few watts for light-emitting diode (LED) lights and mobile phone chargers to several thousand watts for space heaters or air conditioners. First, appliances are classified into tiers based on their power ratings (see Table 1). Then, each household's appliance tier is determined by the highest tier of all its appliances, that is, if a household owns multiple

appliances, the highest-capacity appliance determines the household tier.[8] Capacity is measured in watts for grids, mini-grids, and fossil-fuel-based generators, and in watt-hours for rechargeable batteries, solar lanterns, solar lighting systems (SLSs), and solar home systems (SHSs). It may be difficult to determine the Capacity of the system by simple observation. An estimate of the available Capacity may be done based on the source of the supply (for example, grid power is considered ≥2,000 watts) or the appliances used (Table 1).

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

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

- **Quality** ("Will voltage fluctuations damage my appliances?"): The Quality of the electricity supply refers to the absence of severe voltage fluctuations that can damage a household's appliances. Electric appliances generally require a certain level of voltage to operate properly. Low or fluctuating voltage can damage appliances, and even result in electrical fires. A low or fluctuating voltage supply tends to result from an overloaded distribution system or from long-distance low-tension cables connecting spread-out households to a single grid. The MTF survey does not measure voltage fluctuation directly but uses incidents of appliance damage as a proxy. In this report, the Quality attribute is measured for households connected to the grid or mini-grid.

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

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

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

[8] Households' MTF Capacity tier, furthermore, is determined based on their appliance tier and the main source of electricity. While a household's appliance tier is the major determinant of its allocation in the MTF ranking, there is not a one-to-one correspondence, since the source of electricity plays a role too. Please note that grid-connected households are automatically assigned to Tier 5 for the Capacity attribute regardless of their appliance ownership, so Capacity is discussed for off-grid households only.

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

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, Table A1.1). A household's overall Access Tier is determined by the lowest tier value the household obtains among the attributes. The distribution of the final aggregated tiers and also the individual attribute tiers can then be shown for all households at the national level, according to urban or rural residence, and by the gender of the household head.

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

Despite the well-documented benefits of access to clean cookstoves, around 3 billion of the world's population still use polluting and inefficient cooking solutions. The inefficient use of solid fuels has significant impacts on health, socioeconomic development, gender equality, education, and climate (Ekouevi and Tuntivate 2012; UNDP and WHO 2009; World Bank 2011).[9] The consequences of inefficient energy use for cooking extend beyond direct health impacts. Such use also affects socioeconomic development. For example, fuel collection and cooking tasks are often carried out by women and girls. Collection time depends on the local availability of fuel and may reach up to several hours a day (ESMAP 2004; Gwavuya et al. 2012; Parikh 2011; Wang et al. 2013). The time spent on fuel collection and preparation often translates into lost opportunities for gaining education and increasing income (Blackden and Wodon 2006; Clancy, Skutsch, and Bachelor 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 1).

- **Cooking Exposure** ("How is the user's respiratory health affected?"): This attribute assesses personal exposure to pollutants from cooking activities. Personal exposure, in turn, depends on stove emissions and ventilation (affected by, among other variables, the location of the stove and also the size of the kitchen enclosure, if applicable).[10] Thus, Cooking Exposure is a proxy indicator to measure the health impacts of cooking activity on a household's primary cook. This attribute is a composite measurement of the emissions from the cooking solution (that is, a combination of the stove type and fuel), mitigated by the ventilation in the cooking area. Each of these components has one or more subcomponents. The Cooking Exposure Tier is assigned as a composite of the Emissions and Ventilation Tiers and is weighted by the amount of time spent on each stove, if a household relies on multiple stove types.

- **Cookstove Efficiency** ("How much fuel will a person need to use the stove?"): This attribute is a combination of combustion efficiency and heat-transfer efficiency. Laboratory testing of the efficiency

[9] Household air pollution has been associated with a wide range of adverse health impacts, such as an increased risk of acute lower respiratory infections among children under age 5 and chronic obstructive pulmonary disease and lung cancer (in relation to coal use) among adults over age 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).

[10] In this report, ventilation is defined as using a chimney, hood, or other exhaust system while using a stove or having doors or windows in the cooking area. The ventilation factor plays a role in mitigating pollutants from cooking.

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.[11]

- **Convenience** ("How long does it take to gather and prepare the fuel and the stove before a person can cook?"): This attribute is measured by the amount of time a household spends collecting or purchasing fuel and preparing the fuel and stove for cooking. Convenience is measured through two indicators: the amount of time household members spend collecting or purchasing cooking fuel and preparing the fuel (in minutes per week), and the amount of time needed to prepare the cookstove for cooking (in minutes per meal).

- **Safety of Primary Cookstove** ("Is it safe to use the stove?"): The degree of risk to life and limb can vary by type of cookstove and fuel used. Risks may include exposure to hot surfaces, fire, or potential for fuel splatter. This attribute is measured through reported incidences of past injury and/or fire.

- **Affordability** ("Can a household afford to pay for both the stove and the fuel?"): This attribute assesses a household's ability to pay for the primary cooking solution (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 its total expenditure on cooking fuel. For the purposes of this analysis, the cost of the cookstove is not taken into account.

- **Fuel Availability** ("Is the fuel available when a person needs it?"): The Availability of a given fuel can affect the regularity of its use, while shortages in the fuel can force households to switch to inferior fuel types. This attribute assesses the Availability of fuel when needed for cooking purposes.

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

BOX 4 • TYPOLOGY OF COOKSTOVES IN NIGER

In consultation with development partners and government officials, cookstoves in Niger are classified into four categories (see Annex 3), as follows:

- **Three-stone stove:** A pot balanced on three stones or a tripod over an open fire. In general, this stove uses firewood, has a low combustion temperature, and its fire is exposed, leaving a significant percentage of heat to be lost to the ambient air.
- **Traditional stove:** In Niger, some basic wood (malgaches à bois) stoves, charcoal burning stoves (fourneaux à charbon ronds ou carrés), and mineral coal stoves fall within this category. The pot sits for the most part on the fuel, has a low combustion temperature due to poor insulation, and a lot of cold excess primary air because of too many openings.
- **Improved stove:** In Niger, only wood-burning improved stoves can be found. They are locally manufactured (Maisauki). The number of self-made improved mud stoves is negligible. An improved stove has a higher combustion temperature due to an enclosed combustion chamber and some insulation. The pot sits above the fire, allowing more time for combustion.
- **Clean fuel stove:** Stoves that use a clean burning fuel. In Niger, these are liquefied petroleum gas stoves.

[11] In cases where the cookstove also serves as a source of heating for the dwelling, the Efficiency attribute is ignored because heat-transfer efficiency becomes irrelevant. The Cookstove Efficiency attribute could not be taken into account in assessing access to modern cooking solutions in Niger due to the absence of laboratory testing for those cookstoves used in the country.

USING THE MULTI-TIER FRAMEWORK TO DRIVE POLICY AND INVESTMENT

The MTF survey provides detailed data on household energy consumption that is valuable 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 grid, off-grid, and cooking solutions; and the satisfaction of consumers 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 that the new connections should target.

MTF data can inform the design of interventions meant to expand access, 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 variables that keep households in lower tiers and key barriers, such as lack of generation capacity, high energy costs, or a poor transmission and distribution network. Access interventions can thus be targeted to maximize household access. MTF data also provide guidance on the technologies that are most suited to satisfy the demand of non-electrified households (for example, grid or off-grid). MTF demand-side data, such as on energy spending, WTP, energy use, and appliances, can also be used to 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 expenditure quintile, and by the gender of the household head. For the gender-disaggregated data, non-energy information, such as socioeconomic status, is also collected. Indicators such as primary energy source, tier of access, energy-related spending, WTP, and user preferences are disaggregated by male- 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 NIGER

MTF data collection in Niger started on February 3, 2018, and ended on April 2, 2018. The household survey sample selection was based on a stratified household sampling by (i) region, (ii) urban/rural location, and (iii) connection to the national electricity grid (or not), and aimed at being nationally representative. A two-degree sample selection was applied. The first degree corresponds to the enumeration area (EA) selection. For each region, the sampling frame used was the exhaustive list of all EAs from the latest population census dating from 2012 (4ème Recensement Général de la Population et de l'Habitat). The first degree sample was drawn independently in each strata. A total of 344 EAs were drawn randomly, proportional to their size and according to their electrification status. This includes 138 urban EAs and 139 rural EAs.[12] An additional sample of 67 urban EAs was drawn, independent of their electrification status.

[12] Rural areas of the Diffa region were not covered for security reasons.

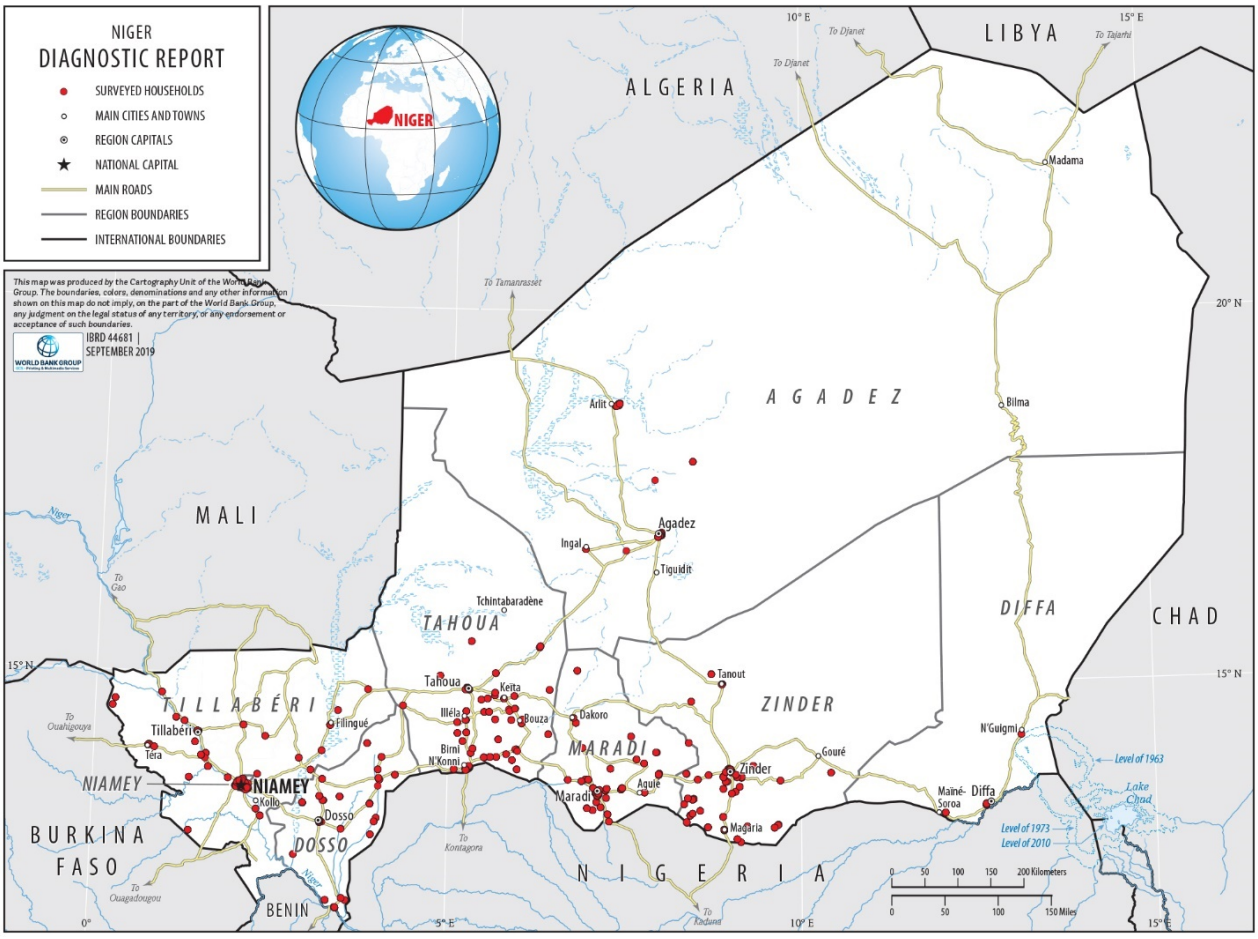
A comprehensive list of households was compiled in the sample EAs, of which 12 households each were systematically selected. A total of 4,071 households were surveyed—2,412 in urban areas (including an oversample of 804 in 7 main cities excluding Diffa) and 1,659 in rural areas.

TABLE 2 • **Distribution of final enumeration areas and sampled households, MTF Survey, Niger**

State/Region	Urban				Rural				Total	
	Electrified		Nonelectrified		Electrified		Nonelectrified			
	EAs	HHs	EAs	HHs	EAs	HHs	EAs	HHs	EAs	HHs
Agadez	8	96	8	108	2	24	2	24	20	252
Diffa	3	36	2	24					5	60
Dosso	8	106	4	47	10	120	7	84	29	357
Maradi	10	167	10	178	15	192	10	120	45	657
Niamey	37	519	25	370			1	12	63	901
Tahoua	13	176	8	106	19	237	13	155	53	674
Tillaberi	6	70	6	69	13	156	9	104	34	399
Zinder	11	166	14	174	21	267	14	164	60	771

Note: EA = enumeration area; HH = household.

MAP 2 • **Sample distribution**



ACCESS TO ELECTRICITY

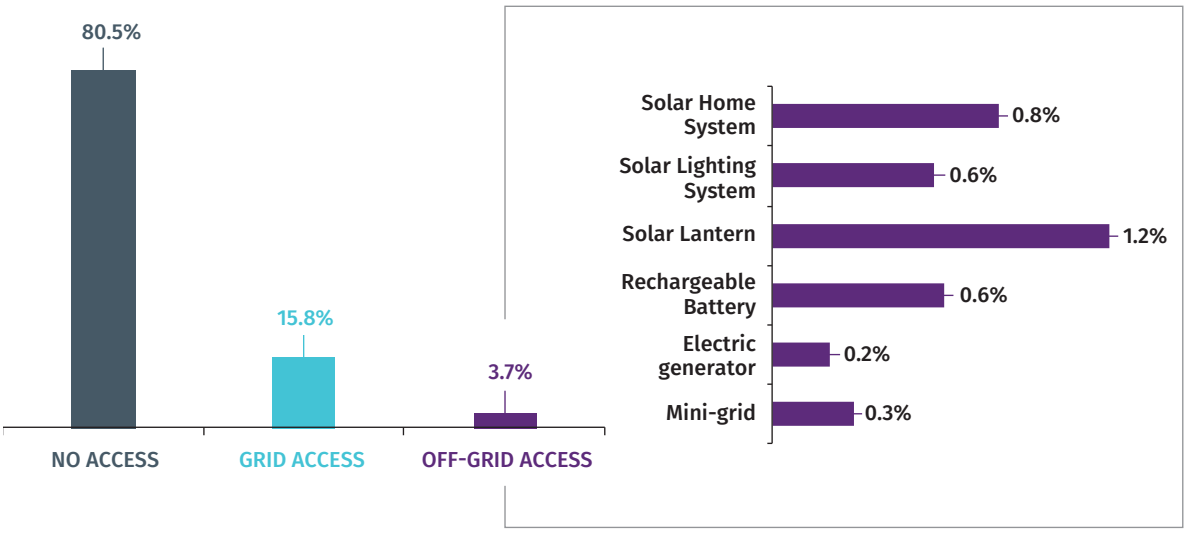
Photo: World Bank

ASSESSING ACCESS TO ELECTRICITY

TECHNOLOGIES

In Niger, 19.5% of households have access to at least one source of electricity: about 15.8% have access to the grid, and 3.7% use off-grid solutions (Figure 3). Solar devices are owned by 2.6% of households, while mini-grids[13] reach only 0.3% of households.

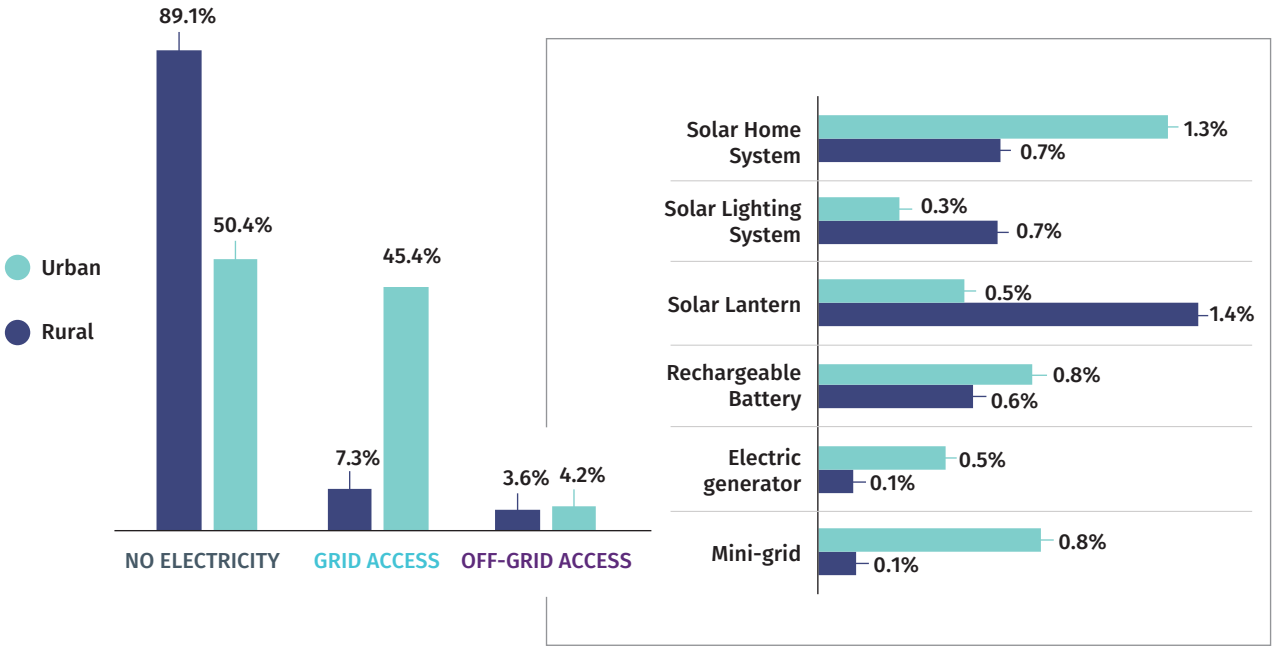
FIGURE 3 • **Access to electricity by technology (nationwide)**



In Niger, 80.5% of households have no access to any source of electricity.[14] The share of households without electricity reaches 89.1% in rural areas, compared to 50.4% in urban areas (Figure 4). Grid usage is more common in urban areas, where 45.4% of households are connected to a grid, compared to only 7.3% of rural households. About 3.6% of rural households use off-grid solutions versus 4.2% of urban households. Rural off-grid households tend to own solar devices, whereas urban off-grid households are as likely to be connected to a mini-grid, or use rechargeable batteries or a generator.

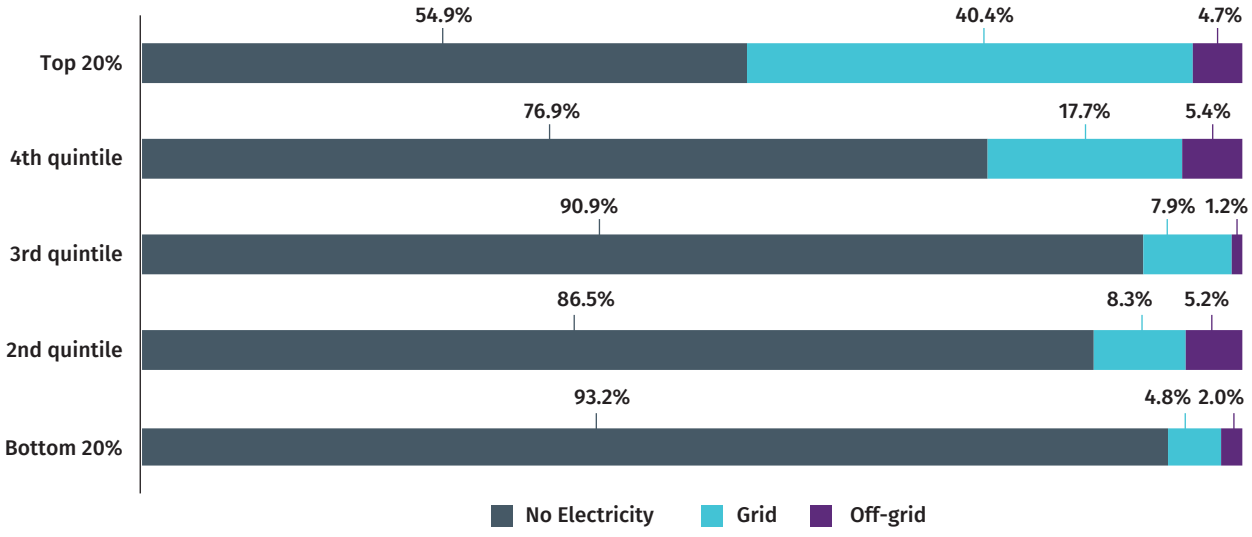
[13] Throughout this report, "mini-grids" refer to NIGELEC-owned mini-grids, which were the only functional mini-grids in operation at the time of the survey.
[14] In this report, and according to the Multi-Tier Framework (MTF) classification, households using dry-cell batteries are not considered as having access to electricity.

FIGURE 4 • **Access to electricity by technology (urban/rural)**



Over 9 in 10 households in the bottom quintile lack access to electricity, while this is the case for less than 6 in 10 households in the highest quintile (Figure 5). The grid access rate increases dramatically with the level of households' expenditure. About 40% of households in the highest expenditure quintile have access to the grid, compared to only 5% of households in the lowest quintile. Off-grid solutions are used among all expenditure quintiles.

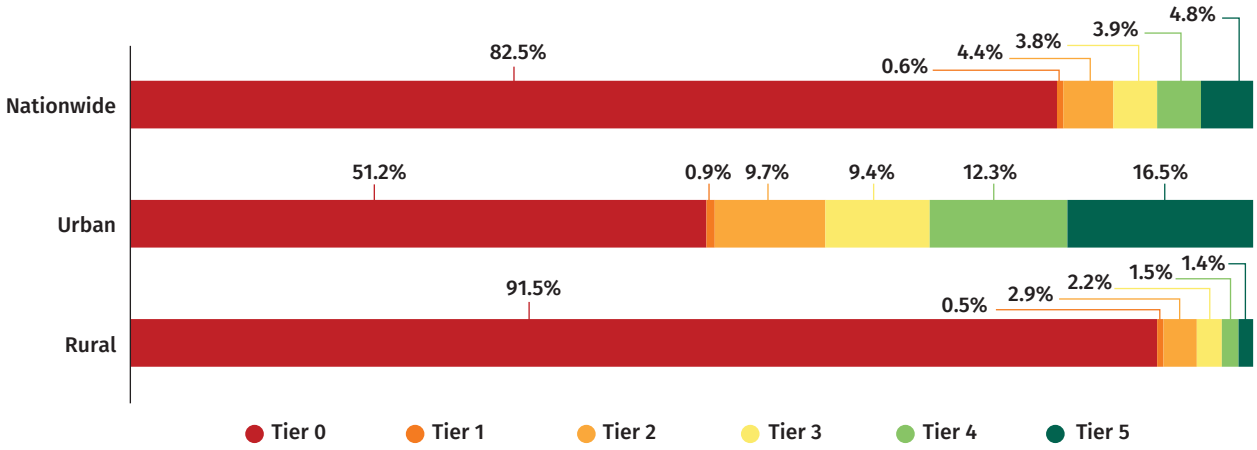
FIGURE 5 • **Access to electricity by technology and across expenditure quintiles (nationwide)**



MTF TIERS

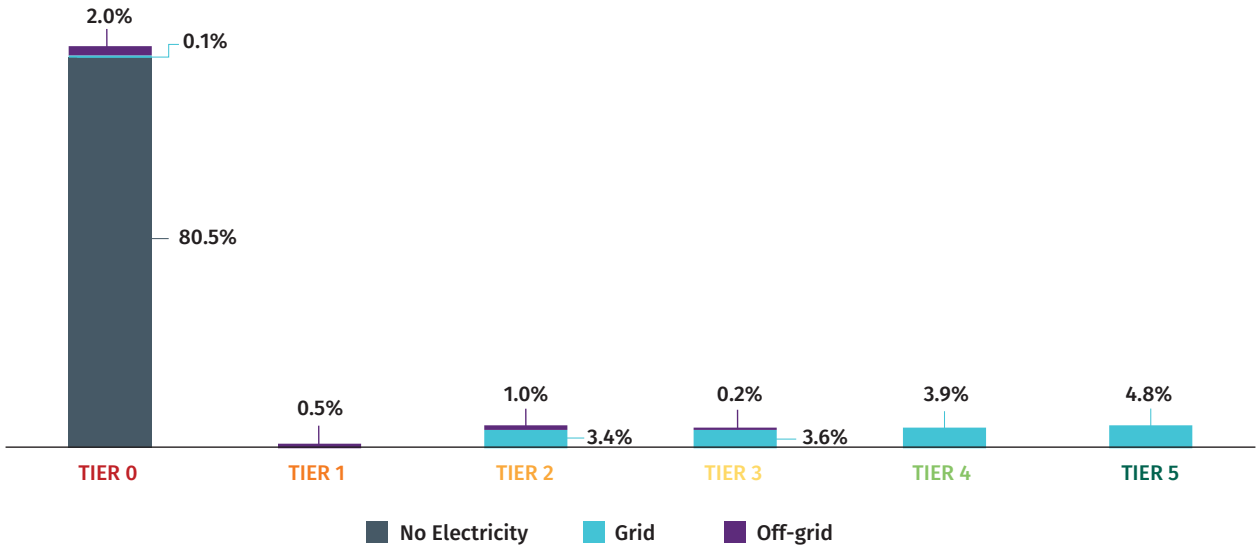
Nationwide, 17.5% of households fall into Tier 1 or above[15] (Figure 6). The share reaches 48.8% in urban areas, while it drops to 8.5% in rural areas. Because of the relatively high penetration of the grid in urban areas, almost 3 in 10 urban households reach Tier 4 or Tier 5.

FIGURE 6 • **MTF Tier distribution (nationwide, urban/rural)**



Almost all households in Tier 2 and above are connected to the grid (Figure 7). Only 0.1% of grid-connected households fall in Tier 1 and below. Off-grid households reach up to Tier 3, but more than half of them are in Tier 0. Of households in Tier 0, almost all lack access to any source of electricity. Only 2.1% of Tier 0 households have access to electricity but their supply does not satisfy Tier 1 requirements (i.e., 3 watts or 12 watt-hours) (see Annex 1, Table A1.1).

FIGURE 7 • **MTF Tier distribution, by technology (nationwide)**



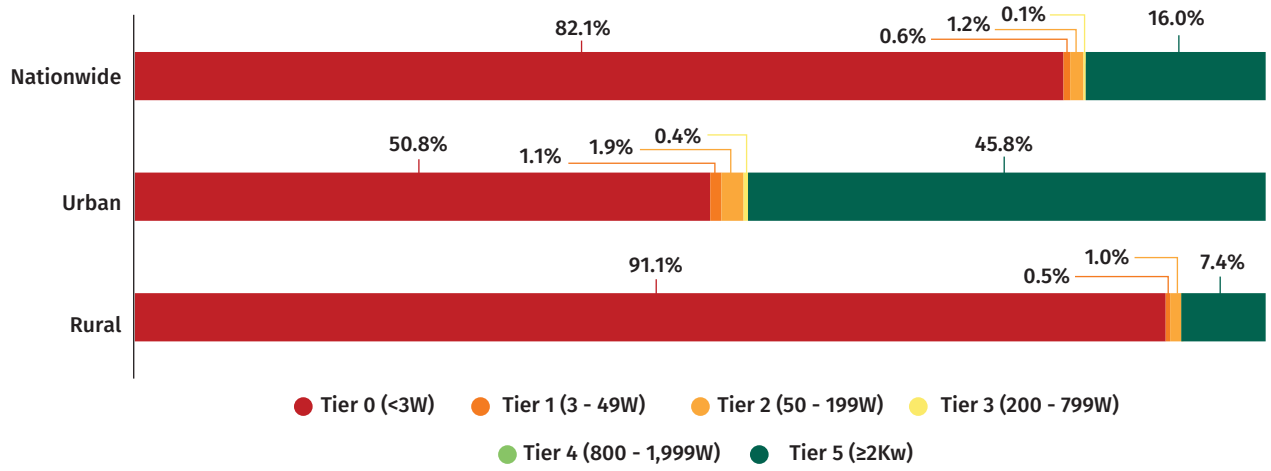
[15] For more details about the MTF tiers, attributes, and formulation, please see Annex 1.

MTF ATTRIBUTES

Capacity

The Capacity of electricity supply denotes the ability of a system to provide a certain amount of electricity to operate various appliances. Assuming that the Capacity of the grid is over 2 kW, all grid-connected households have Tier 5 Capacity (Figure 8). The Capacity of off-grid solutions typically ranges between 3 and 199 watts (Tier 1 and Tier 2) for 2% of households, while only 0.1% of households have a larger off-grid solution (≥200 watts).

FIGURE 8 • **Distribution of households by Capacity (nationwide, urban/rural)**



Availability

The Availability of supply refers to the amount of time during which electricity is available within a 24-hour day and in particular during the evening (from 6pm to 10pm). In Niger, over half of electrified households have electricity for at least 23 hours a day, and over 8 in 10 households have 4 hours of evening supply (Figures 9 and 10). About 5.8% of households receive less than 8 hours of supply per day. The share is higher in rural areas.

FIGURE 9 • **Distribution of households based on daily Availability (over a 24-hour day) (nationwide, urban/rural)**

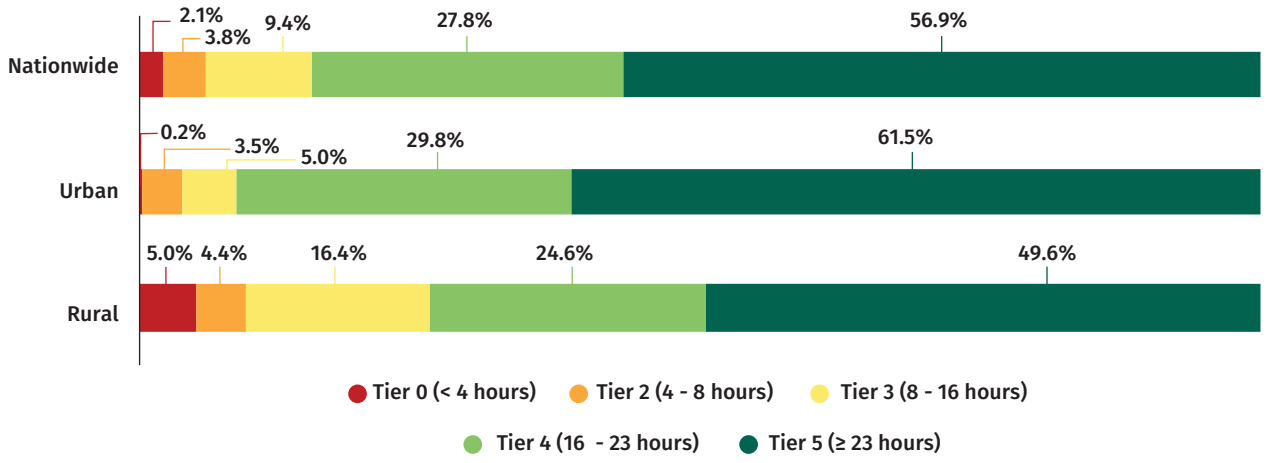
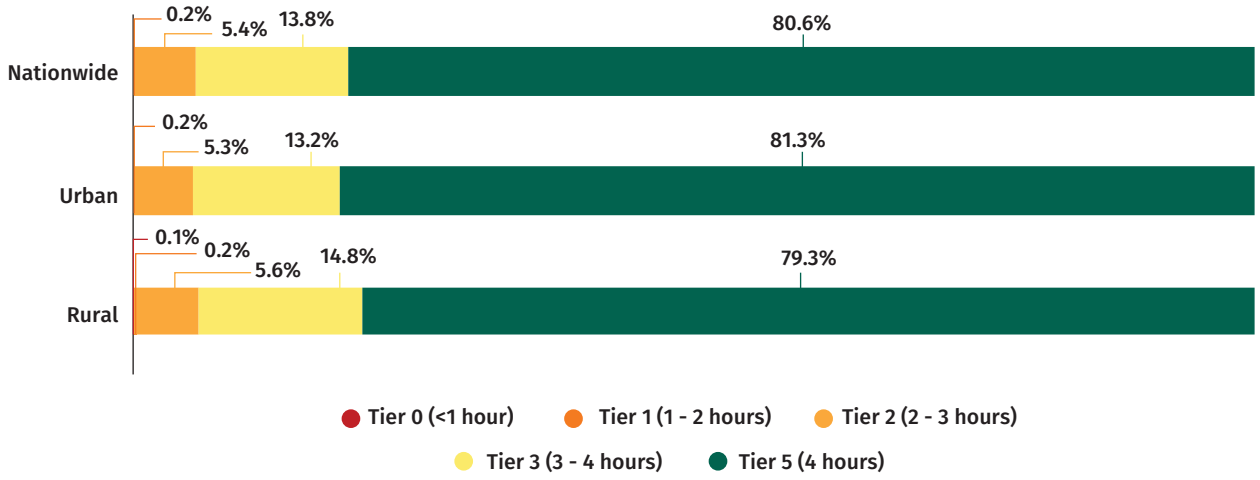


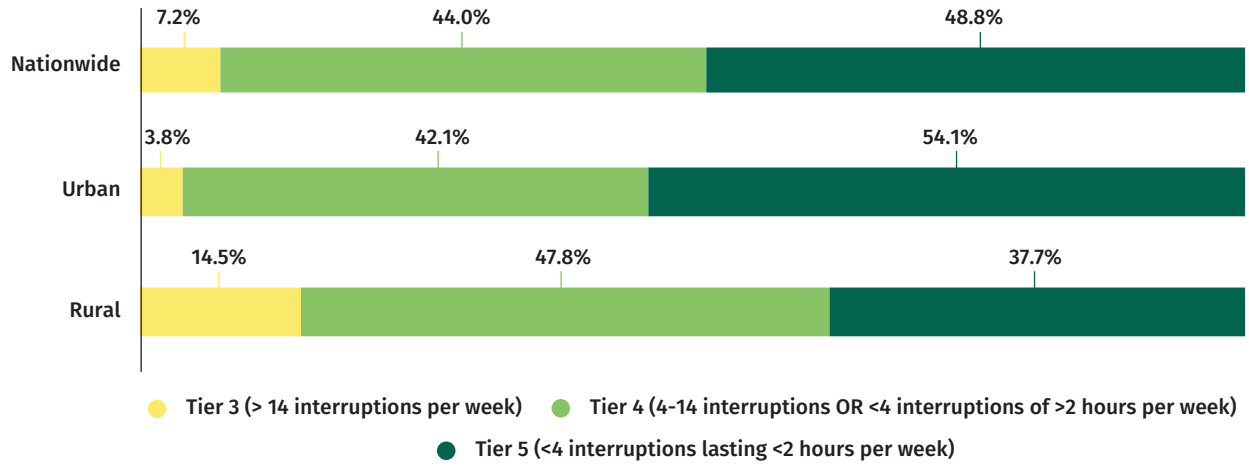
FIGURE 10 • **Distribution of households based on evening Availability (4-hour period) (nationwide, urban/rural)**



Reliability

The Reliability of electricity supply captures the frequency and duration of unscheduled (unexpected) outages, and applies only to grid-connected households. Nationwide, 48.8% of households experience less than four unscheduled outages per week, lasting less than 2 hours in total (Figure 11). The issue of unreliable electricity supply is larger in rural areas, where this share drops to 37.7%. Also, about 7.2% of households reported more than 14 unscheduled interruptions per week. This share is twice as high in rural areas. On average, households in Niger experience unscheduled outages about five times per week lasting about 23 minutes.

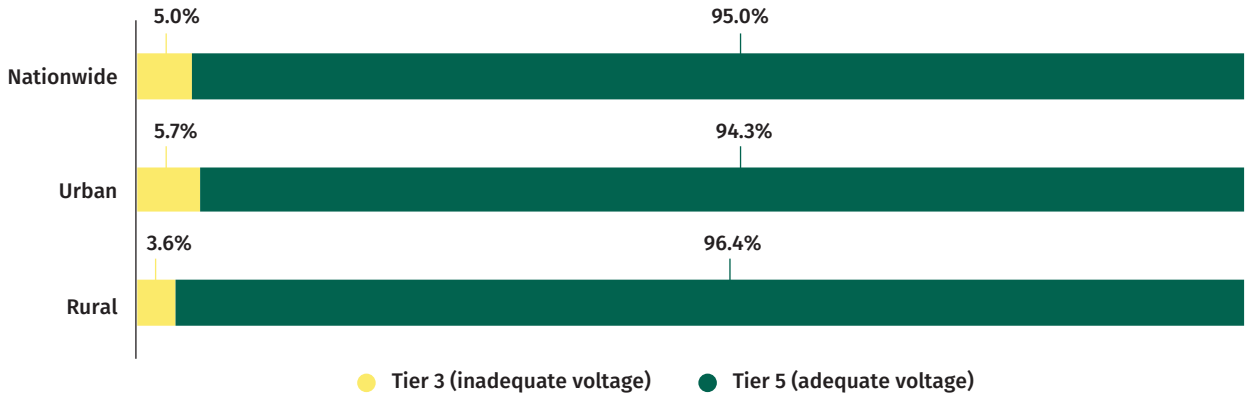
FIGURE 11 • **Distribution of households based on Reliability (nationwide, urban/rural)**



Quality

A low-quality electricity supply is characterized by low or fluctuating voltage, resulting in damage to appliances. This attribute is measured only for households connected to the grid or a mini-grid. Nationwide, only about 5% of households face voltage issues (Figure 12). Quality, as opposed to Reliability, tends to be a slightly larger issue in urban areas.

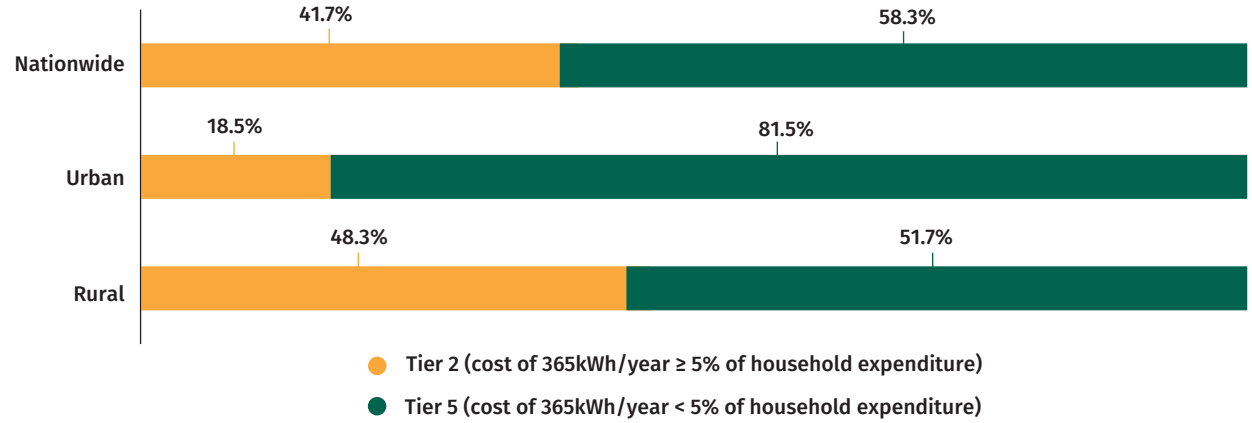
FIGURE 12 • **Distribution of households based on Quality (nationwide, urban/rural)**



Affordability

The Affordability of electricity service is determined by whether the cost of a standard consumption package of 365 kWh a year (or 30 kWh per month) is less or more than 5% of a household's total expenditure. By this metric, service is unaffordable for 48.3% of rural households, and about 18.5% of urban households (Figure 13). The current monthly fixed fee plus 30 kWh consumption corresponds to CFA francs (CFAF) 2,033.5 (US$3.88), according to Niger's national utility company (NIGELEC).[16]

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

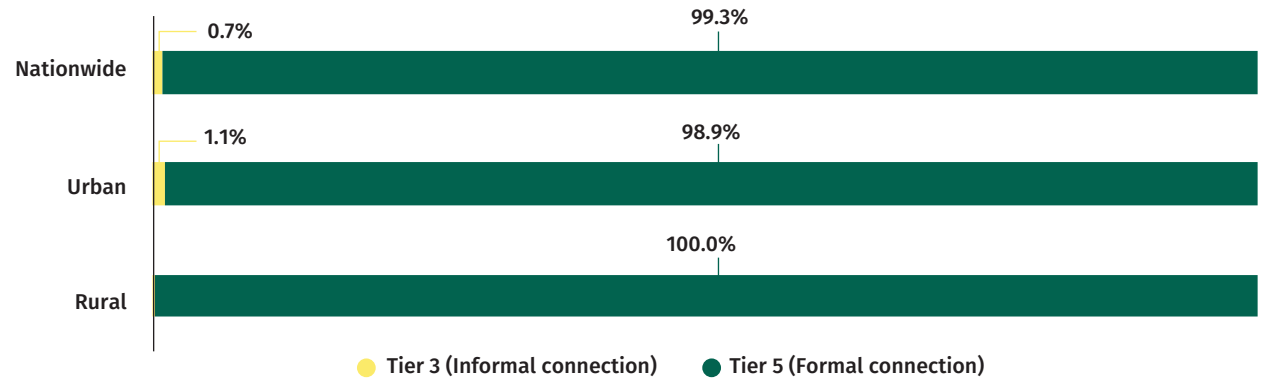


[16] DECRET No2017-796/PRN/ME du 06 octobre 2017 portant approbation de la Méthodologie tarifaire et la structure des tarifs applicables aux usagers finaux du service public de l'énergie électrique fourni par la Société Nigérienne d'Electricité (NIGELEC).

Formality

A formal connection is one that has been provided or sanctioned by a governing authority. This attribute is measured only for households connected to the grid or a mini-grid. In Niger, it is estimated that 0.7% of connected households have an informal connection (Figure 14). Reporting on Formality is a challenge since 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 a connection through indirect questions that respondents may be more willing to answer (such as whom a household member pays for electricity service).

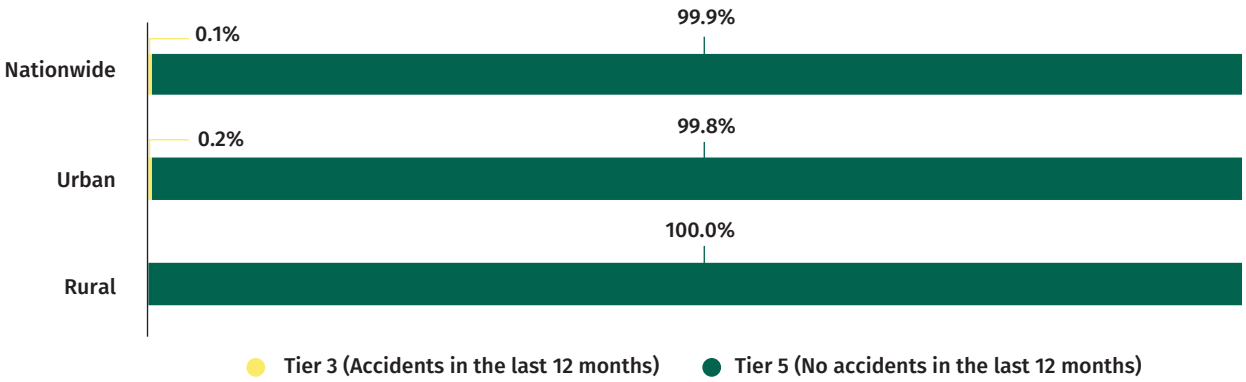
FIGURE 14 • **Distribution of households based on Formality (nationwide, urban/rural)**



Health and safety

Health and Safety are inferred based on self-reported accidents related to electricity (such as faulty internal wiring or incorrect use of appliances) over the 12 months preceding the survey. In Niger, electricity supply from the grid is generally safe; 0.1 % of the households surveyed reported permanent limb damage or death because of electrocution. In urban areas, 0.2% of households reported serious injuries due to electrocution (Figure 15); no rural households report such injuries. To prevent accidents, households must be encouraged to install all wiring according to national standards, and all household members must be made aware of basic safety measures.

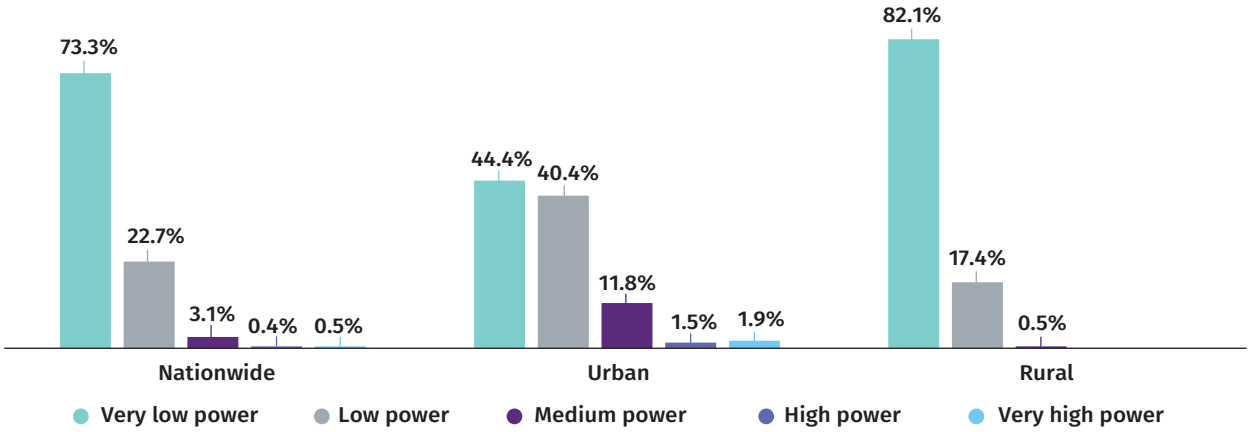
FIGURE 15 • **Distribution of households based on Health and Safety (nationwide, urban/rural)**



USE

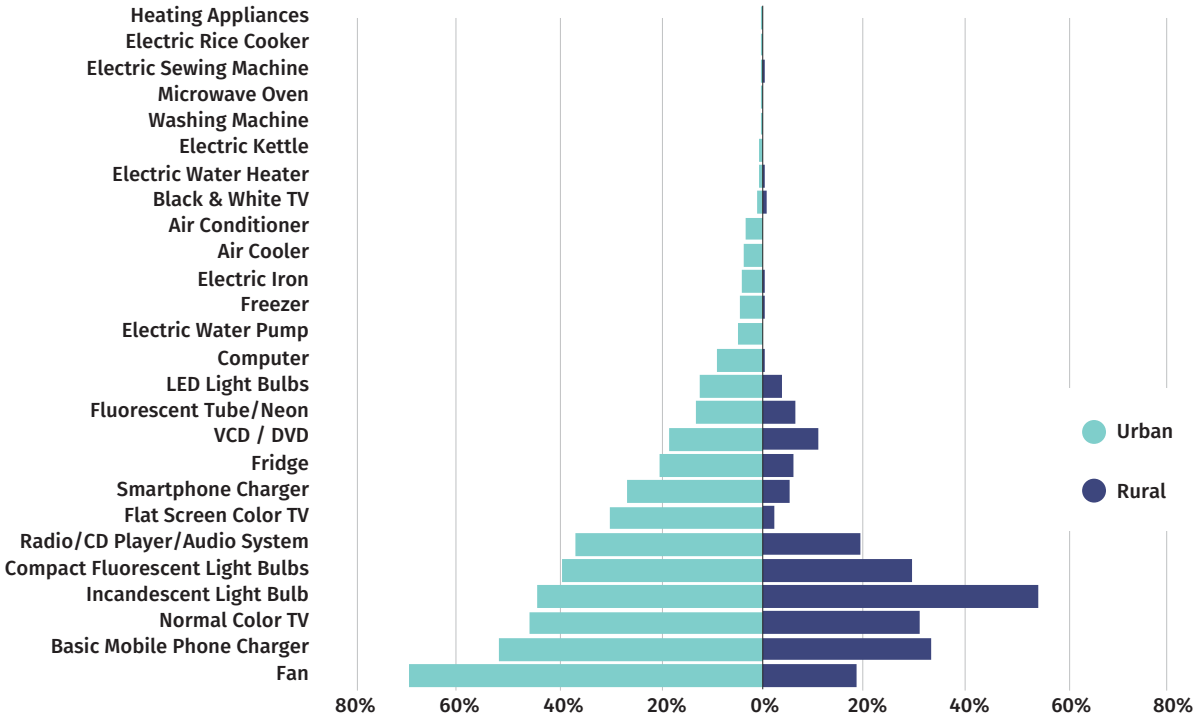
Households in Niger mainly use low and very low power appliances (Figure 16). The penetration of high and very high load appliances is minimal in urban areas and almost non-existent in rural areas. Medium load appliances are more common in urban areas, where one in five households owns at least one.

FIGURE 16 • **Household ownership of appliances by load level (nationwide, urban/rural)**



The top five most common appliances owned by grid-connected households in urban areas are fans (70%), mobile phone chargers (52%), televisions (46%), and incandescent light bulbs (44%) and CFL bulbs (39%) (Figure 17). In rural areas, grid-connected households mainly own incandescent light bulbs (54%), mobile phone chargers (33%), televisions (31%), CFL bulbs (29%), and radios or audio systems (19%). Refrigerators are fairly common in urban areas, where one in five households owns one. The rest of the appliances are owned by only a small percentage of households.

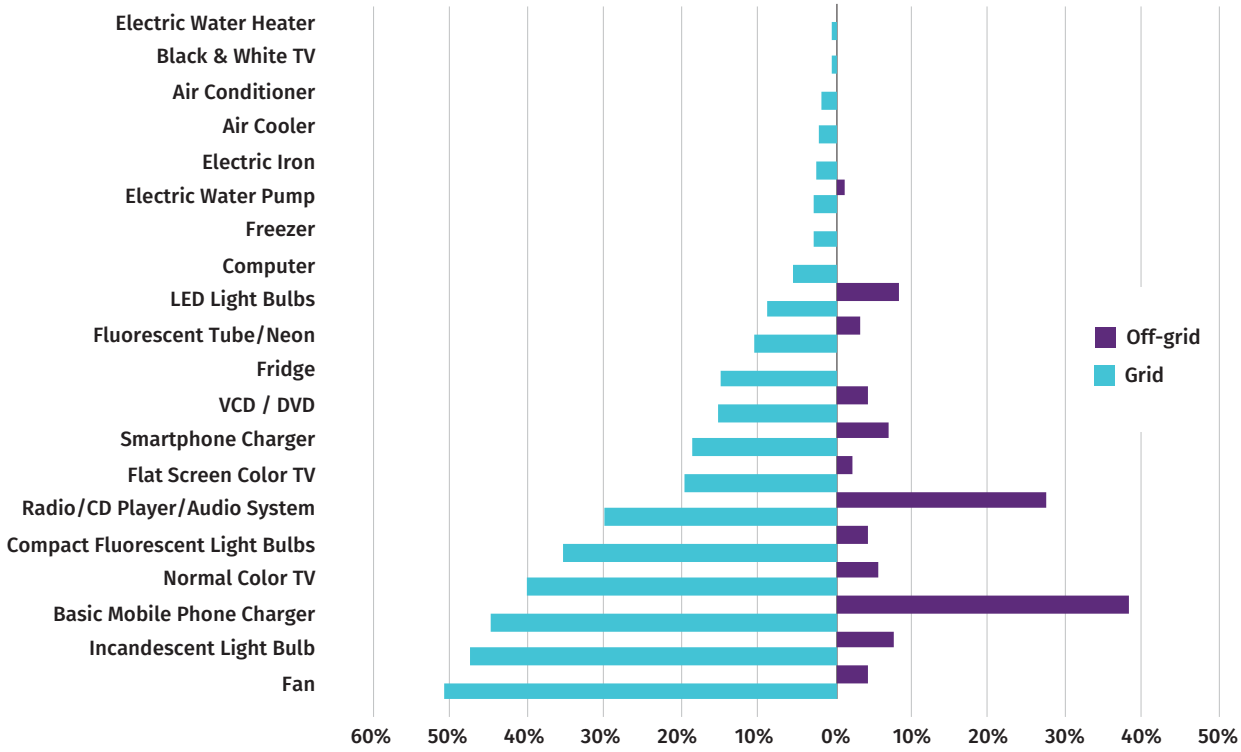
FIGURE 17 • **Types of appliances owned by grid-connected households (urban/rural)**



Note: CD = compact disc; LED = light-emitting diode; VCD = video compact disc.

Appliance ownership differs notably between grid-connected and off-grid households (Figure 18). A larger share of grid-connected households use electrical appliances than do off-grid households. Off-grid users mostly own very low load appliances, while grid-connected households use a diverse array of appliances including medium load and some high load ones.

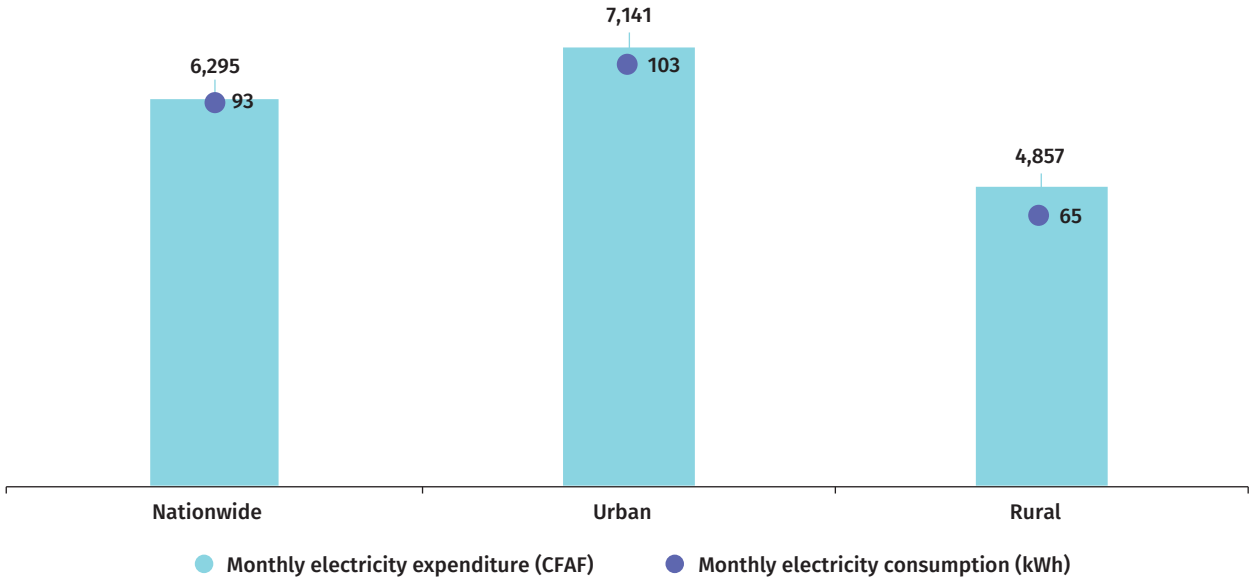
FIGURE 18 • **Types of appliances owned by households with grid and off-grid solutions (nationwide)**



Note: CD = compact disc; LED = light-emitting diode; VCD = video compact disc.

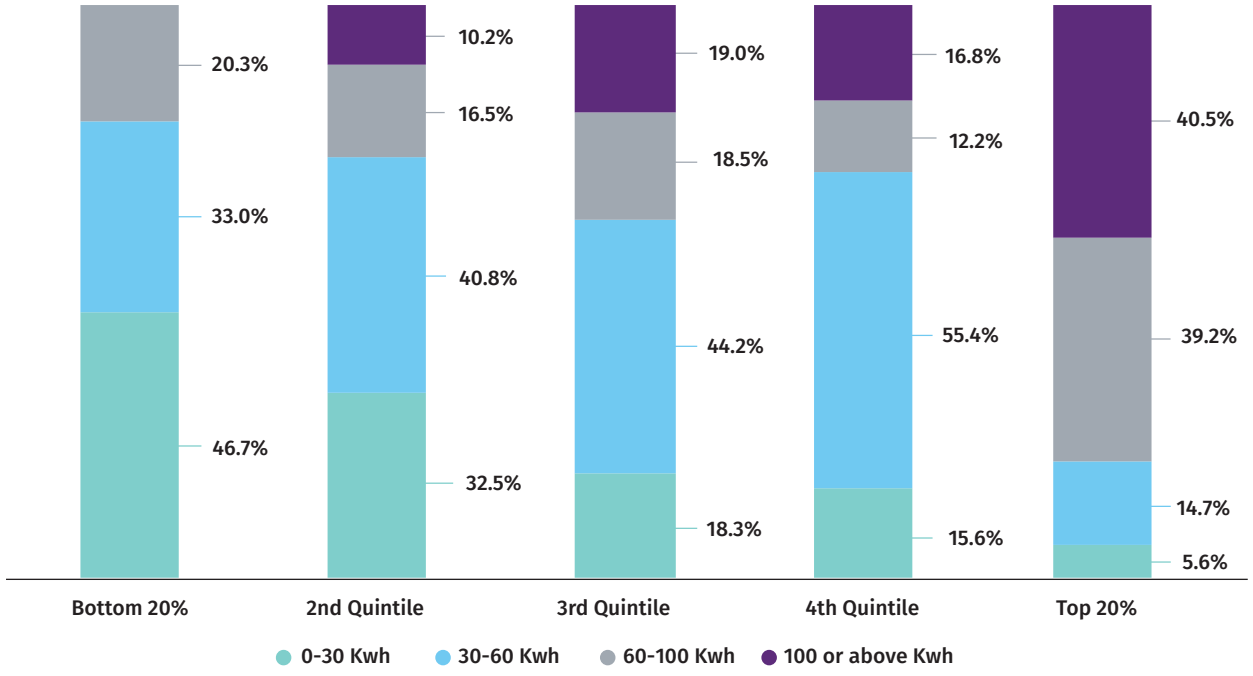
In Niger, grid-connected households consume an average of 93 kWh per month. Monthly consumption falls to 65 kWh for rural households and reaches 103 kWh for urban households (Figure 19). On average, households spend CFAF 6,295 (US$12) per month on electricity, corresponding to 6.6% of an average household's expenditure. Rural households tend to consume less electricity (CFAF 4,857 or US$9.26 per month). Urban households have been connected to the grid for an average of 7.1 years and rural households for 5.4 years.

FIGURE 19 • **Monthly household expenditure on and consumption of electricity (nationwide, urban/rural)**



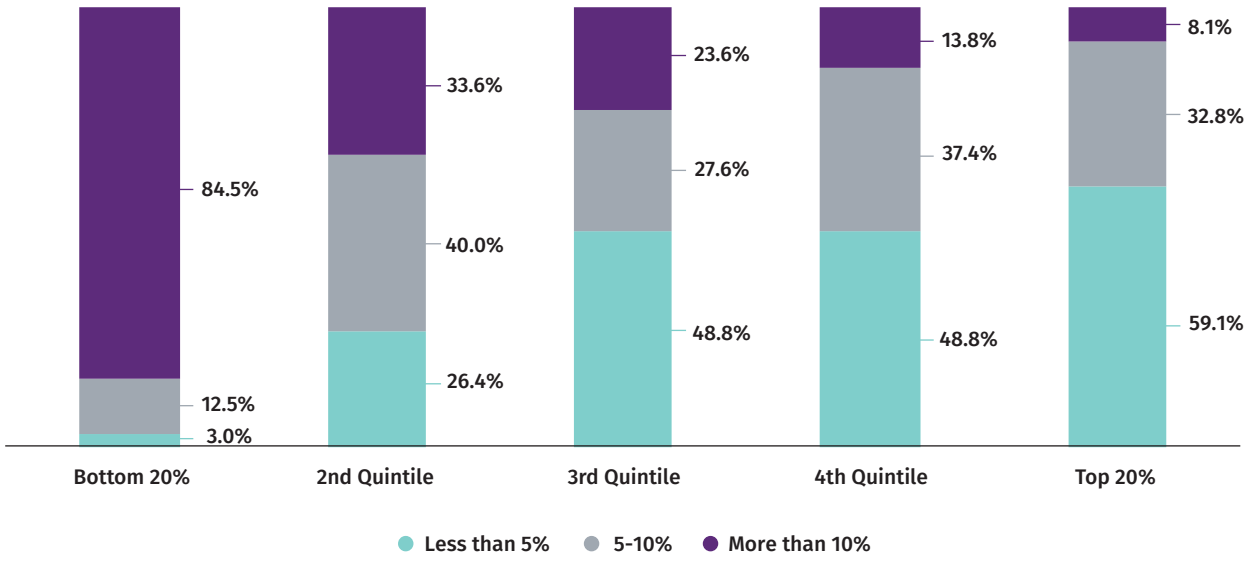
Almost half the households in the lowest expenditure quintile consume 1 kWh per day or less (Figure 20). Electricity consumption rises as expenditure quintiles increase: no households in the bottom quintile consume 100 kWh or over per month, versus 40.5% of the top spending quintile.

FIGURE 20 • **Monthly grid electricity consumption by expenditure quintile (nationwide)**



Spending on electricity is, however, disproportionately burdensome for lower spending quintiles (Figure 21). A mere 3% of households in the bottom quintile spend less than 5% of their household budget on electricity, while 84.5% of them spend over 10%. Conversely, less than 1 in 10 households in the top quintile spend more than 10% of their household budget on electricity.

FIGURE 21 • **Share of household budget spent on grid electricity by expenditure quintile (nationwide)**



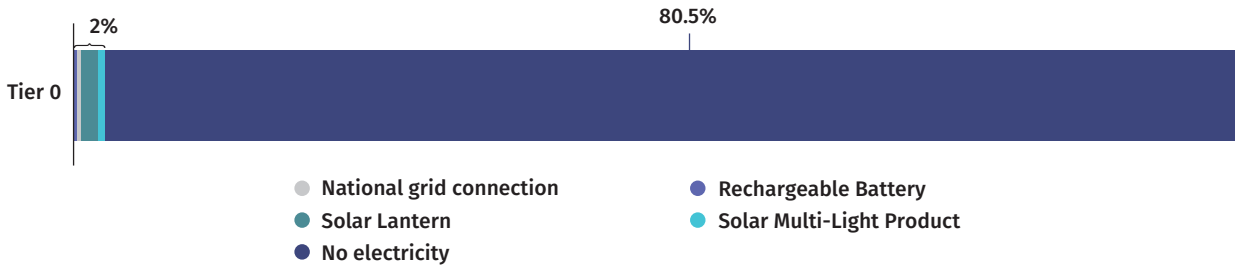
IMPROVING ACCESS TO ELECTRICITY

PROVIDING ELECTRICITY ACCESS TO HOUSEHOLDS WITHOUT A SOURCE OF ELECTRICITY

In Niger, 82.5% of households are in Tier 0 for electricity access, with a larger share located in rural areas that are less covered by the national grid network and sometimes difficult to reach. Virtually all households in Tier 0 have no electricity source (Figure 22).

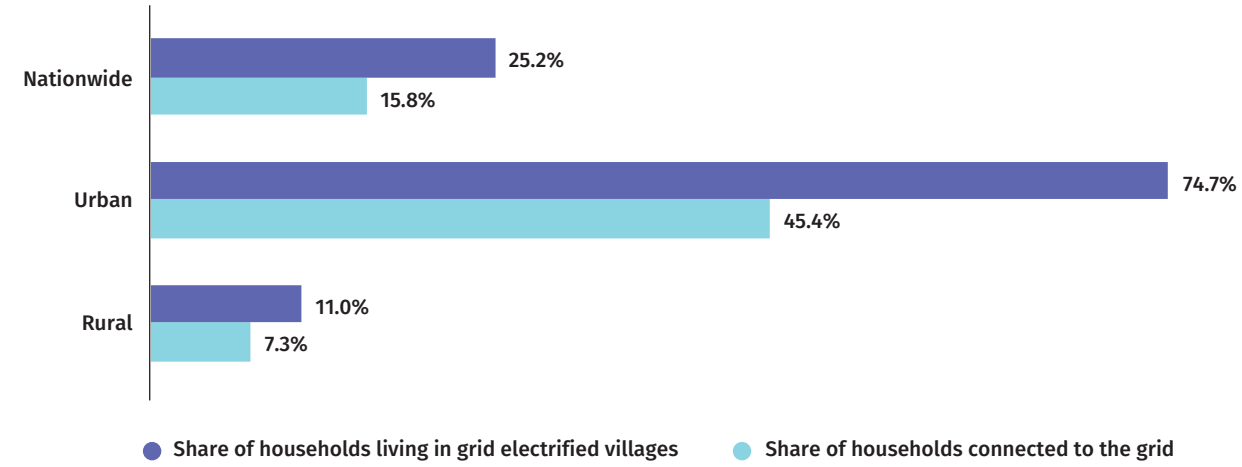
Strategies for shifting households to higher tiers are best determined by the barriers keeping certain households in a low tier. For example, it will be helpful to provide on- or off-grid solutions to those without electricity or to improve the Availability of electricity supply for those using electricity service.

FIGURE 22 • **MTF Tier 0 disaggregation, by source of electricity (nationwide)**



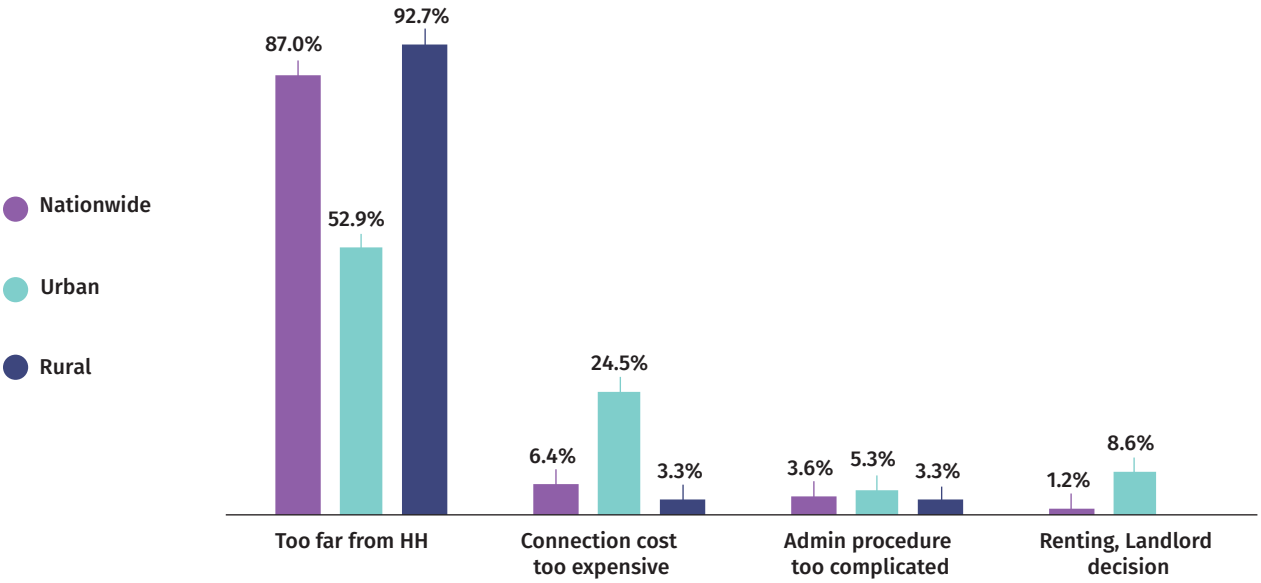
About 15.8% of households in Niger are connected to the grid. Meanwhile, 25.2% of households are located in communities where a grid connection is available (i.e., where at least one household is connected to the grid) (Figure 23). This means that in grid-electrified communities, only about three in five households are connected to the grid. Thus, densification projects may enable about 9.4% of households nationwide to get access to the existing grid. In urban areas, densification may reach almost 30% of households.

FIGURE 23 • **Comparison between village electrification and household electrification rates (nationwide, urban/rural)**



The barriers preventing households from gaining a connection are as follows: the distance to the grid (87%), the high up-front cost of obtaining grid access (6.4%), and delays or difficulties in the administrative process (3.6%) (Figure 24). Distance to the grid is a more acute issue in rural areas (92.7%), connection cost also pose a major constraint in urban areas (24.5%).

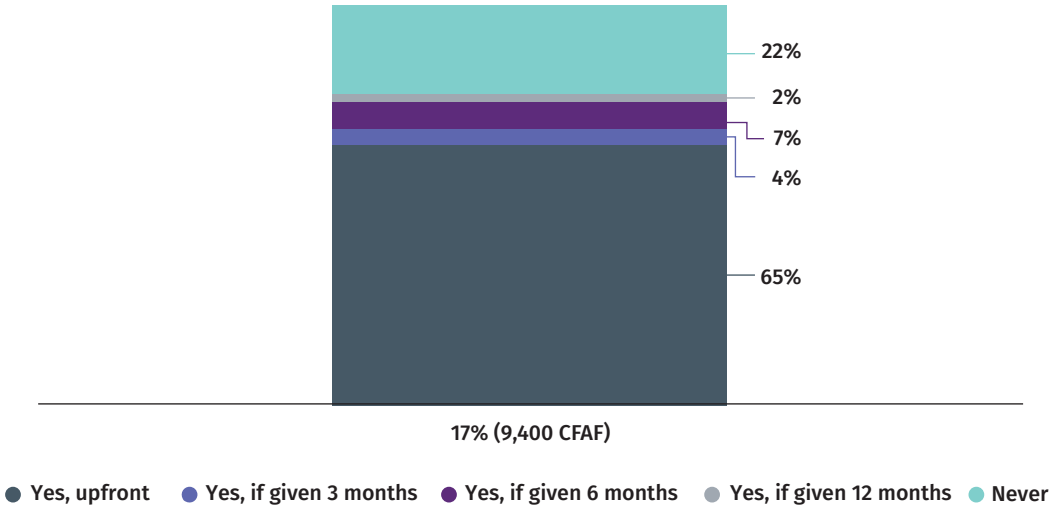
FIGURE 24 • **Barriers to gaining access to grid electricity (nationwide, urban/rural)**



Note: HH = household.

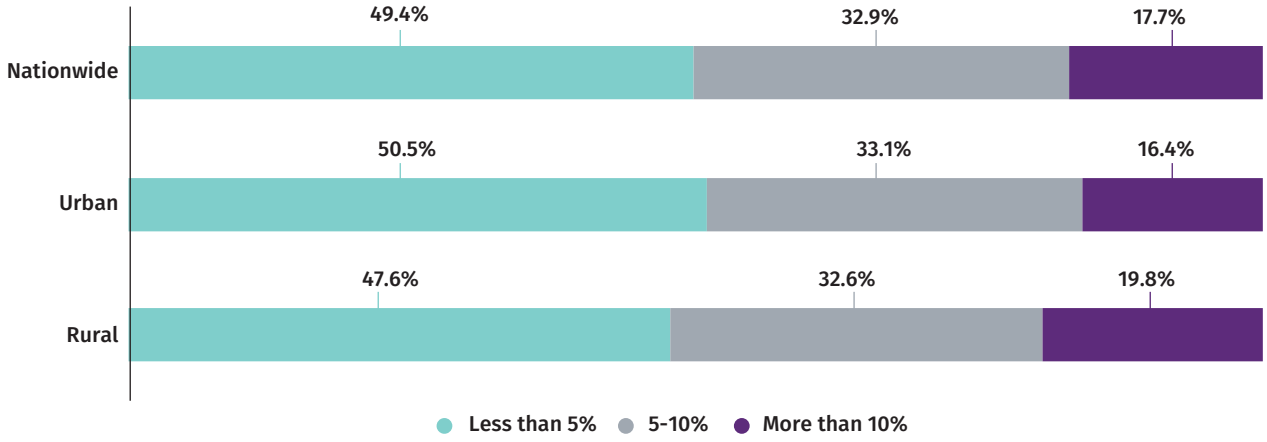
To effectively address the high up-front financial cost of connecting to a grid (that is, a fee of CFAF 54,242 or US$103.4), well-targeted subsidies might be an option to consider. When unconnected households nationwide were asked if they were willing to pay for access to the national grid, at a subsidized price, a majority reacted positively. If the connection cost was brought down to 17% of the total cost, 65% were willing to pay CFAF 9,400 (Figure 25). Along with this, proposing a flexible payment plan could further increase the uptake rate of the national grid: 78% of unconnected households were willing to pay for the subsidized connection cost (CFAF 9,400) provided it could be paid in installments.

FIGURE 25 • **Willingness to pay for the grid connection fee (nationwide)**



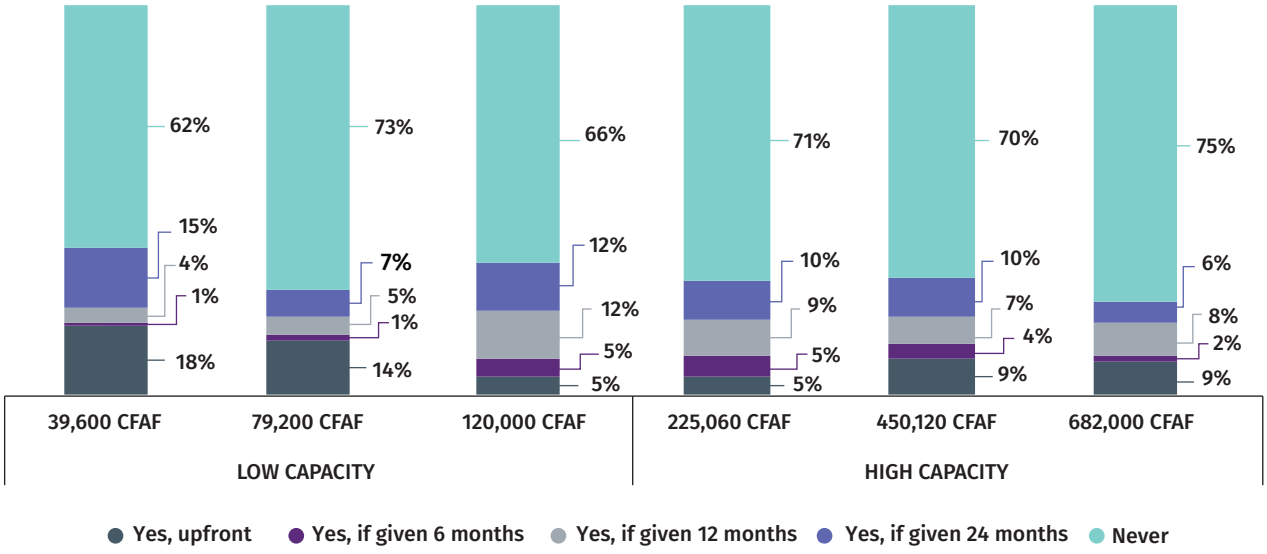
The large majority of unconnected households that are not willing to pay for a grid connection (82.4%) reported that they cannot afford the wiring costs. These findings point to a need to design and implement more comprehensive policies for grid densification. Also, the financing options may help households not only to pay the official grid connection fee but also any associated costs. This point is valid across the country, as spending on electricity was found to be a financial burden for all households, affecting rural ones a little more severely (Figure 26).

FIGURE 26 • **Distribution of households by share of budget spent on electricity (nationwide, urban/rural)**



Nationwide, the use of solar devices is still in its infancy. On average, households have been using solar devices for less than 2.5 years. Willingness to pay for solar home systems (SHSs) increases as the price drops (Figure 27). Although only 25% of households are willing to pay for a high-capacity SHS at the full price of CFAF 682,000 (US$1,300.7), the share reaches 38% for a low-capacity SHS priced at CFAF 39,000 (US$74.4) (corresponding to one-third of the initial price). Depending on the price, 13% to 29% of households were interested in flexible payment options (installments over 6, 12, and 24 months).

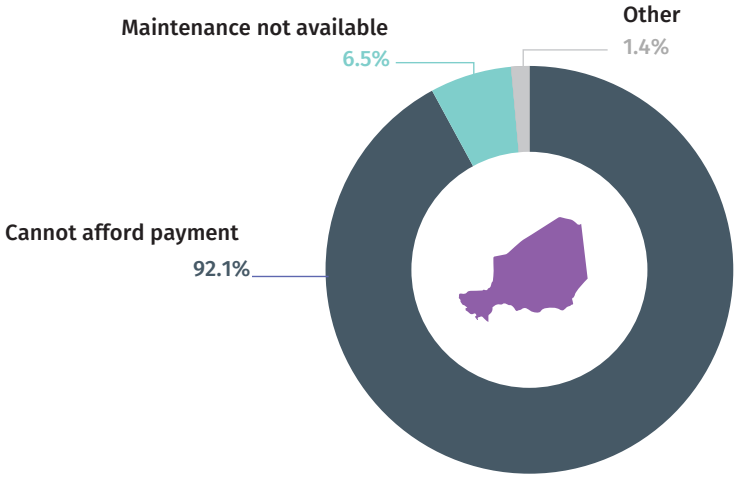
FIGURE 27 • **Willingness to pay for a solar home system (nationwide)**



Note: Here, a low-capacity SHS corresponds to a 5-watt system and a high-capacity SHS corresponds to a 150-watt system.

The large majority of households (92.1%) are not willing to pay for a solar device under any price or payment plan, due to Affordability issues (Figure 28). Only 6.5% of households considered maintenance to be a barrier. Thus, Affordability is important to address when promoting access to off-grid solar solutions.

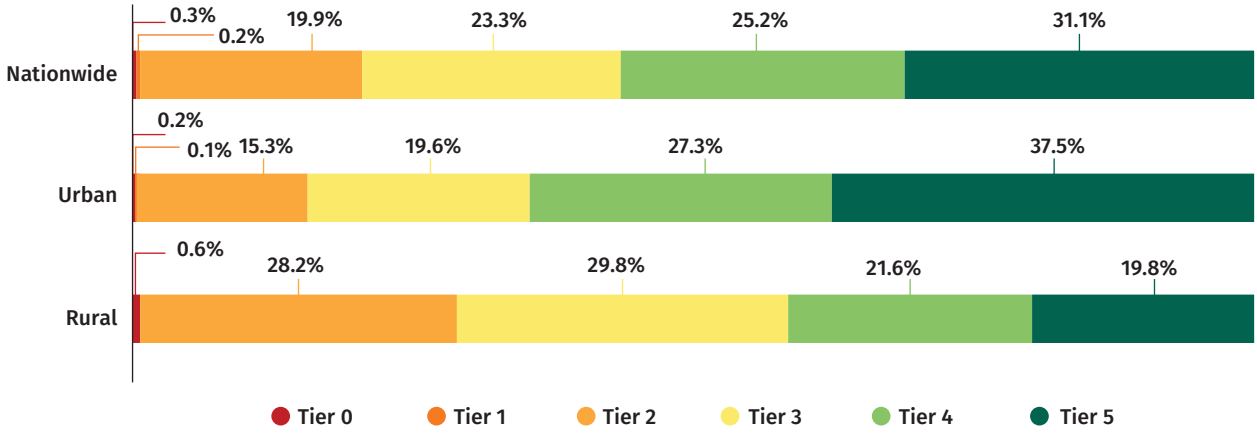
FIGURE 28 • **Reasons cited by households for not being willing to pay for a solar home system (nationwide)**



IMPROVING ELECTRICITY ACCESS AMONG GRID-CONNECTED HOUSEHOLDS

In Niger, the national grid provides a fair Quality of service to consumers (Figure 29). Nationwide, four in five grid-connected households (79.6%) are in Tier 3 or above, while nearly one in three households (31.1%) reach Tier 5 access. The remaining 20.4% of grid users suffer from poor supply, but mainly fall in Tier 2. Urban households enjoy a better level of access than rural ones.

FIGURE 29 • **MTF Tier distribution of grid-connected households (nationwide, urban/rural)**



More than two-thirds of grid-connected households are not in the highest tier (Tier 5) and could move up to higher tiers. More specifically, improving the Availability, Reliability, and Affordability of electricity supply could eventually shift grid users to the highest tier.

Limited Availability of electricity supply is an issue for 38.6% of grid-connected households in Niger (Figure 30). Most of these households receive between 16 and 23 hours of electricity per day, whereas 8.1% of grid-connected households receive less than 16 hours of electricity per day. Urban households enjoy more hours of electricity service than rural ones. Evening Availability is an issue for about one-fifth of grid-connected households (Figure 31).

FIGURE 30 • **Distribution of grid-connected households based on daily Availability (over a 24-hour day) (nationwide, urban/rural)**

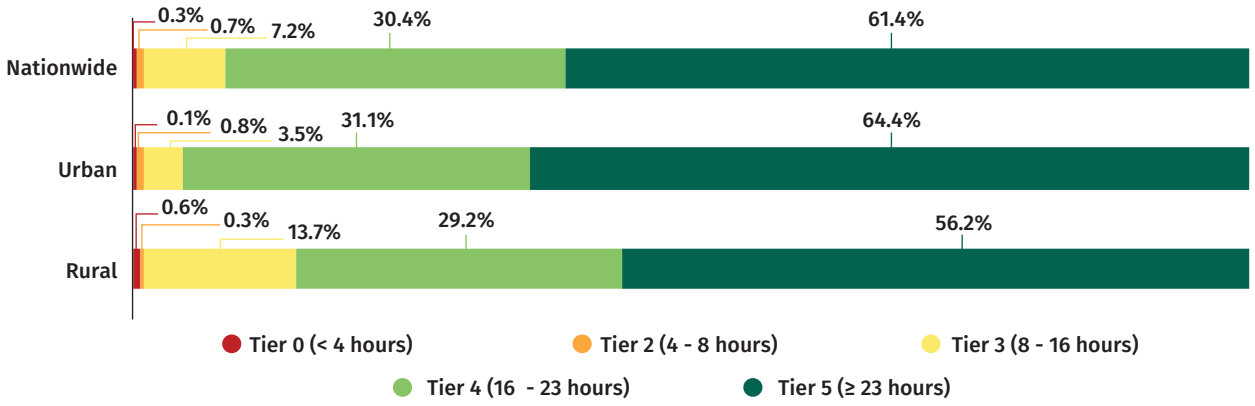
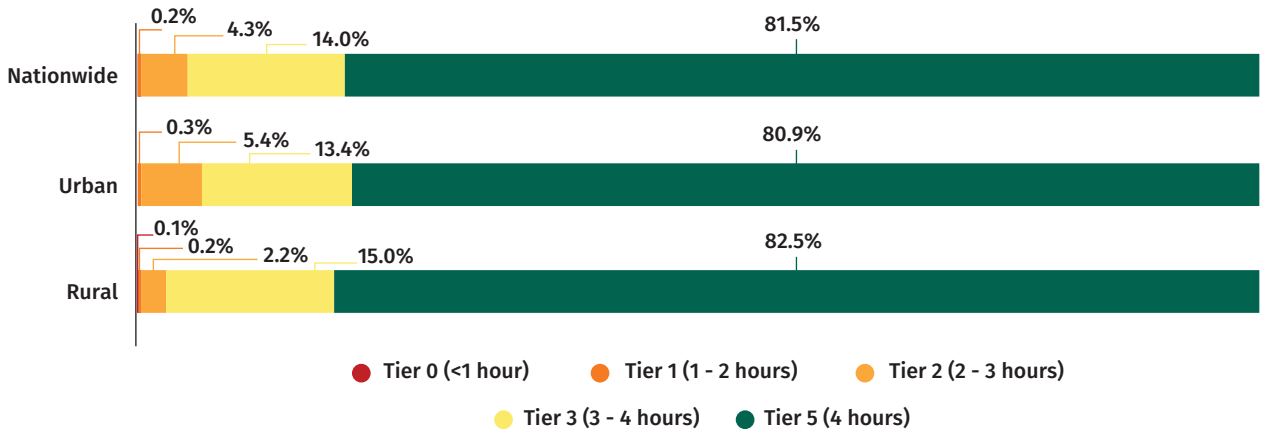
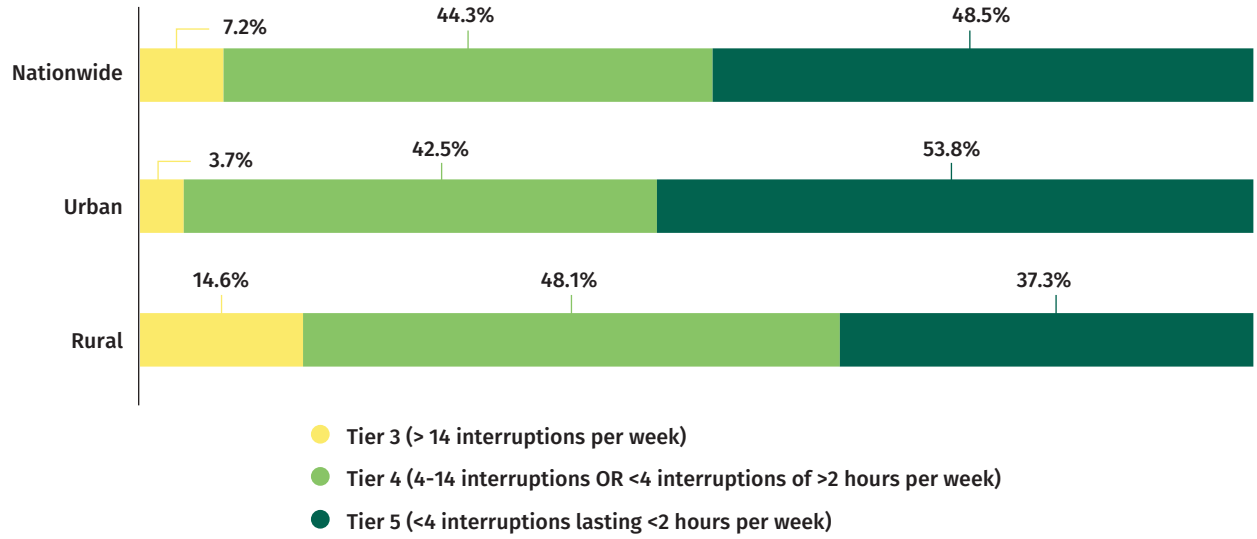


FIGURE 31 • **Distribution of grid-connected households based on evening Availability (4-hour period) (nationwide, urban/rural)**



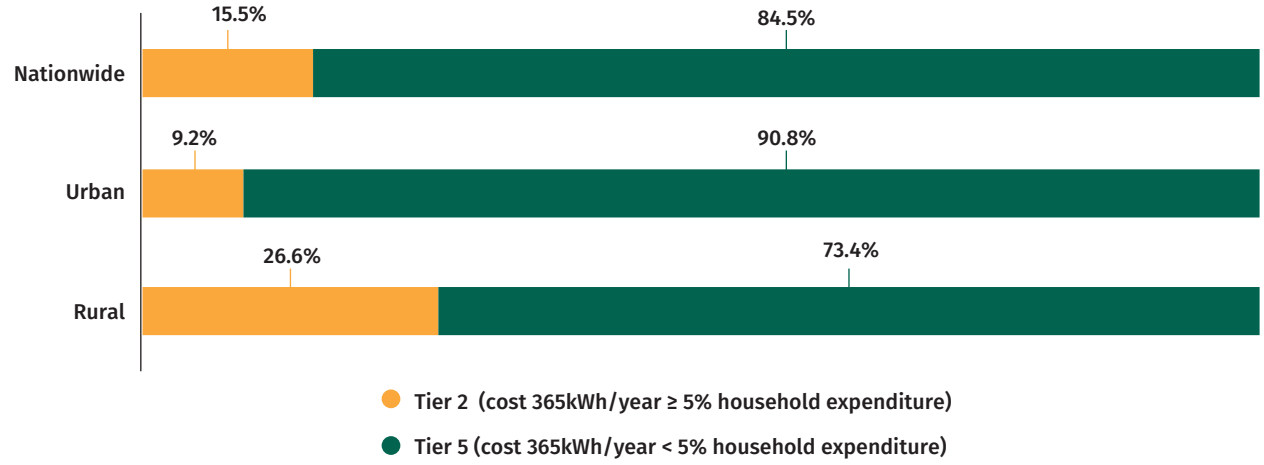
More than half of grid-connected households experience more than three outages a week or more than 2 hours of interruptions (Figure 32). The situation is much better in urban areas, where a mere 3.7% of grid users experience more than 14 interruptions per week—compared to 14.6% of grid-connected rural households.

FIGURE 32 • **Distribution of grid-connected households based on Reliability (nationwide, urban/rural)**



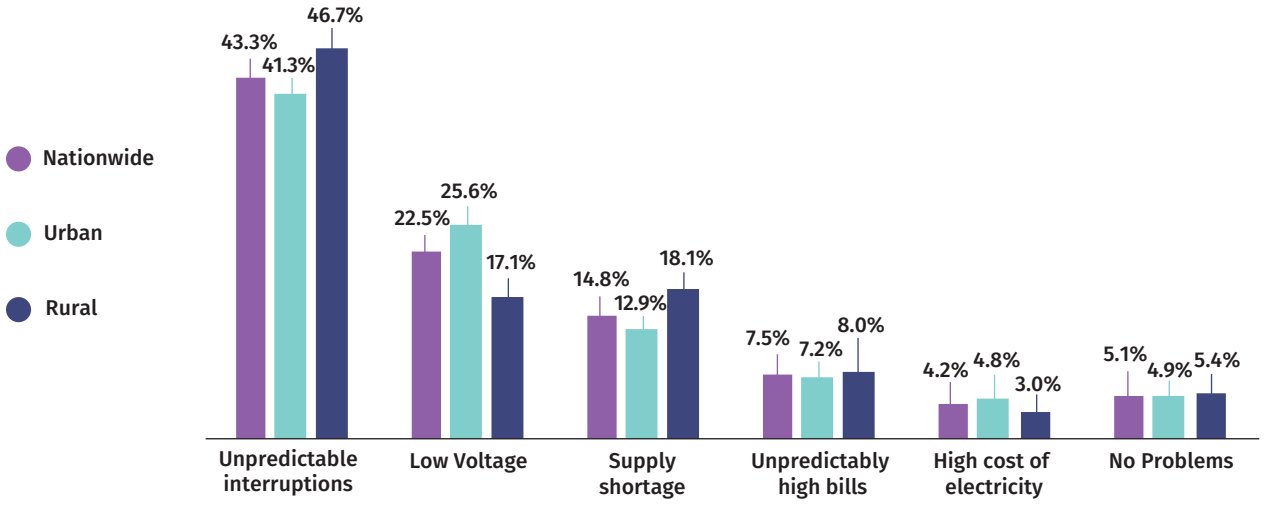
Also, 15.5% of grid-connected households spend more than 5% of their budget on electricity. Rural households are especially affected by Affordability constraints (Figure 33).

FIGURE 33 • **Distribution of grid-connected households based on Affordability (nationwide, urban/rural)**



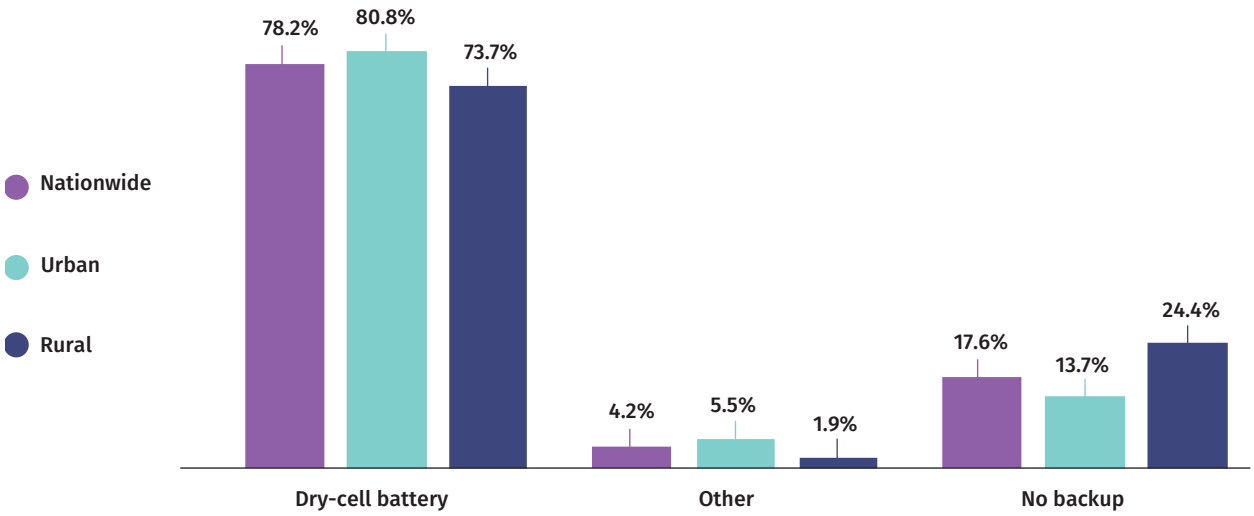
Only 5.1% of grid-connected households reported that they have encountered no issue with their electricity supply (Figure 34). The remaining households reported interruptions, low voltage, supply constraints, and cost as the main problems. These findings are based on consumer perceptions of key issues.

FIGURE 34 • **Main issues related to grid electricity supply (nationwide, urban/rural)**



To cope with power outages, grid-connected households in Niger use dry-cell batteries almost exclusively: 73.7% of rural households and 80.8% of urban households use dry-cell batteries as their backup source of power for lighting (Figure 35). Among grid-connected households, 17.6% do not have any backup source of lighting; and more urban households (86.3%) than rural households (75.6%) use a backup source.

FIGURE 35 • **Share of grid-connected households using a backup power source for lighting (nationwide, urban/rural)**



POLICY RECOMMENDATIONS

A mere 15.8% of households in Niger are connected to the national grid. Among them, nearly one-third (31.1%) are in Tier 5. Improvements in the Availability of electricity (that is, increasing the amount of time during which electricity service is available) and its Reliability (reducing the number and duration of outages) and Affordability (reducing the share of electricity in the household budget) could shift more than two-thirds (68.9%) of the grid-connected households to higher tiers.

Only 3.7% of households use off-grid solutions, including 1.2% who rely on solar lanterns and 0.8% using solar home systems. Government policies are needed to facilitate the development of a market for solar products and their distribution, installation, and maintenance.

More than four-fifths of households (82.5%) are in Tier 0 for electricity access. Virtually all households in Tier 0 have no access to any electricity source. Moving them to higher tiers would require the provision of either grid or off-grid access. The following are policy recommendations for providing electricity to those who do not have access:

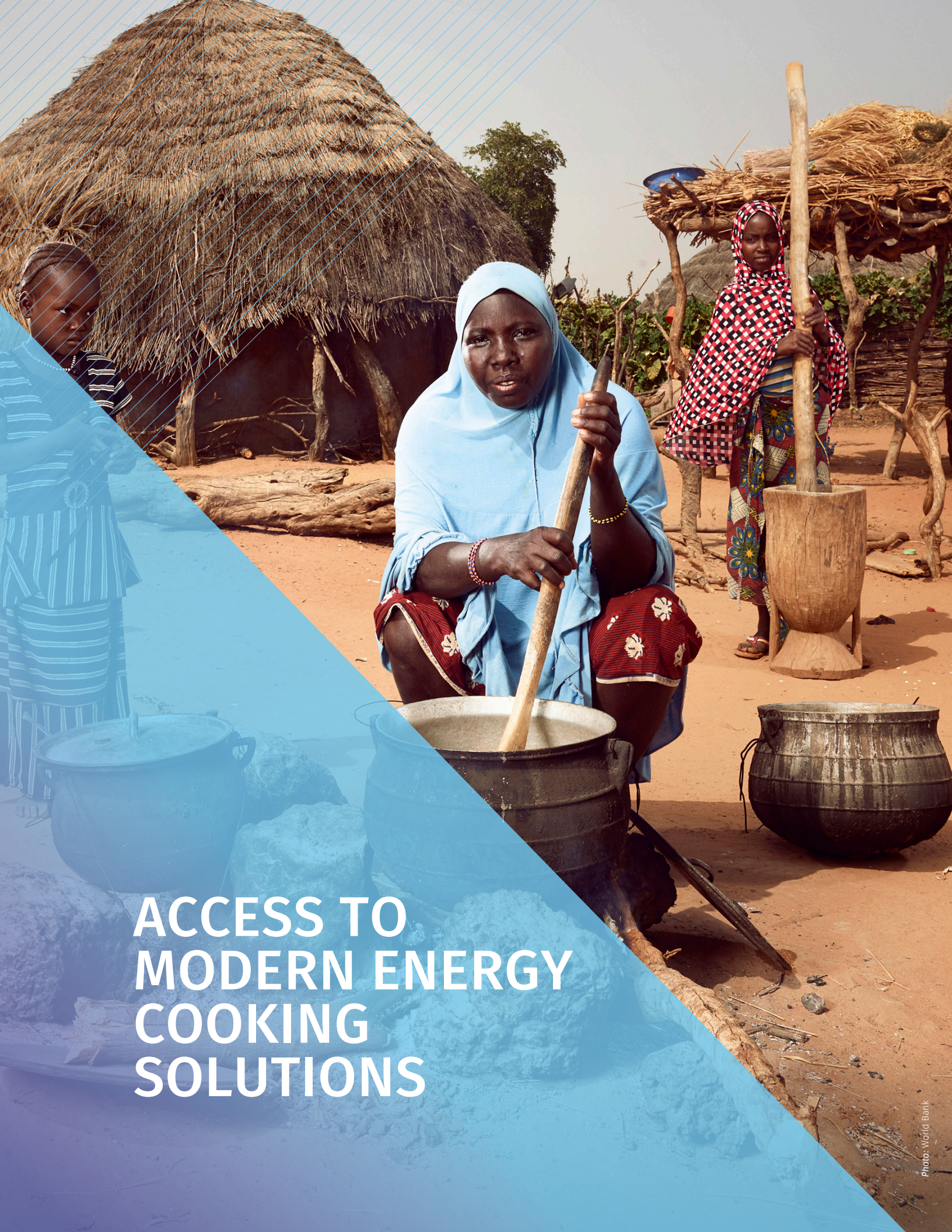
- **Formulate optimal energy solutions with the least cost,** considering the population density, the distance to the national grid network, potential electricity demand from various types of consumers, and the socioeconomic environment. With the advancement in geographic information system (GIS) technology, optimal energy solutions are often devised using the geospatial planning methodology.[17]

- **Densify the grid**, especially by offering longer payment periods and more financing options for the connection cost, which would effectively address the financial barrier of the connection fee that households face. Beyond grid densification, expansion of grid infrastructure can provide electricity to those without electricity as long as this is the lowest-cost approach.[18]

[17] Since the survey was conducted, this has been included in the 2019 National Electrification Strategy (NES).
[18] As per the NES, grid densification and extension are the least-cost solutions toward electrifying 85% of the population by 2035.

- **Consider the development of mini-grids,** especially for settlements located far from the grid infrastructure, and where households have sizeable electricity demand, including for productive uses.

- **Consider introducing off-grid solar products;** this may be a more feasible solution for households living in areas where the grid infrastructure is not available. Although households in Niger have only started using solar devices in recent years, the majority of these solar users seem to be satisfied with the current service. Thus, providing off-grid access through solar devices of at least 3 watts (or 12 watt-hours) can move Tier 0 households to higher tiers (most likely Tier 1 or 2) for access to electricity. Strengthening quality assurance systems coupled with micro-finance and leasing opportunities could increase the adoption of solar devices. Consumer awareness programs could help raise the demand and the willingness to pay, and help potential consumers choose products of adequate quality and use them more sustainably.



ACCESS TO MODERN ENERGY COOKING SOLUTIONS

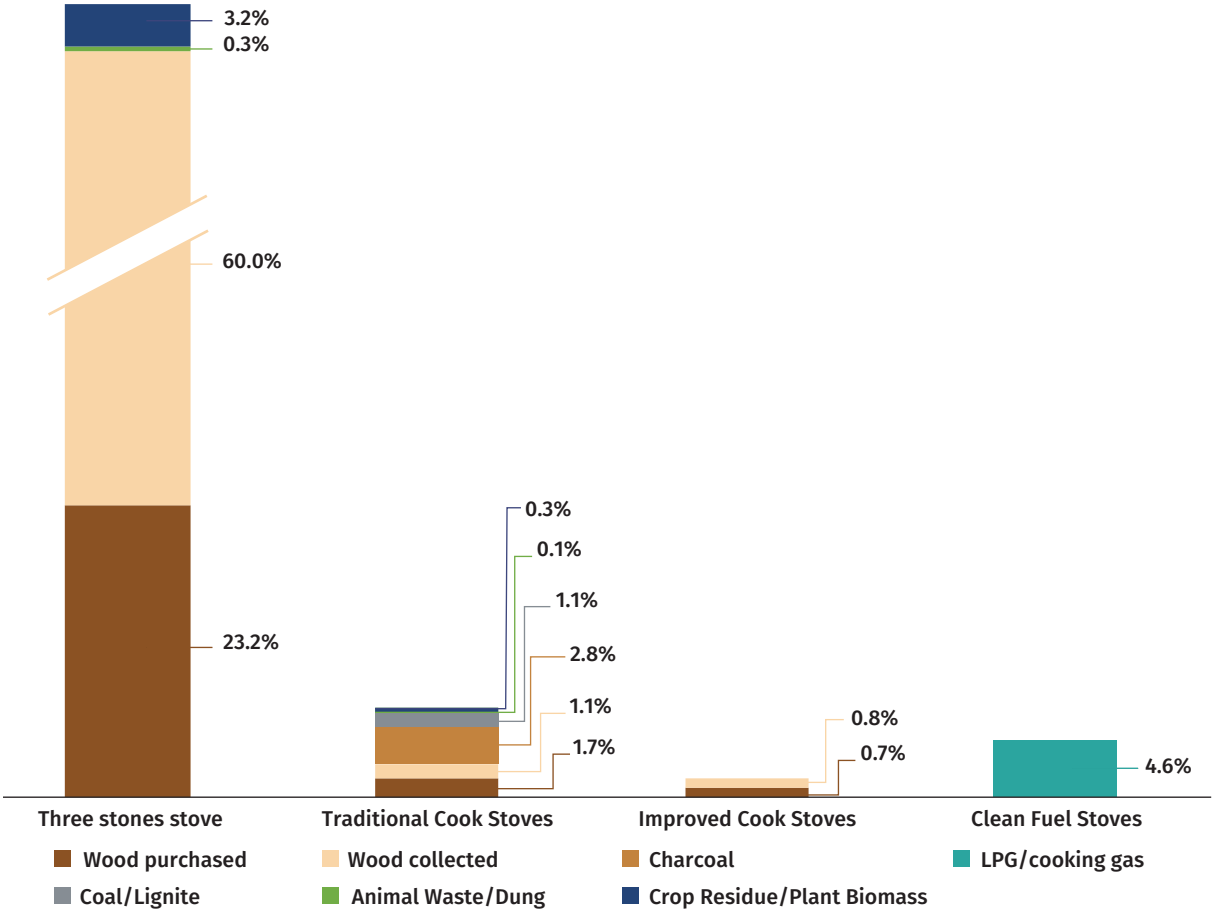
Photo: World Bank

ASSESSING ACCESS TO MODERN ENERGY COOKING SOLUTIONS

TECHNOLOGIES

In Niger, over 90% of households primarily cook with biomass (Figure 36). They almost exclusively use a three-stone stove for burning firewood as their primary cooking solution (83.2%). Improved cookstoves are used by a mere 1.5% of households with firewood, and clean fuel stoves (using liquefied petroleum gas [LPG]) are the primary cooking solution of 4.6% of households.

FIGURE 36 • **Distribution of cookstove types and fuel used (nationwide)**

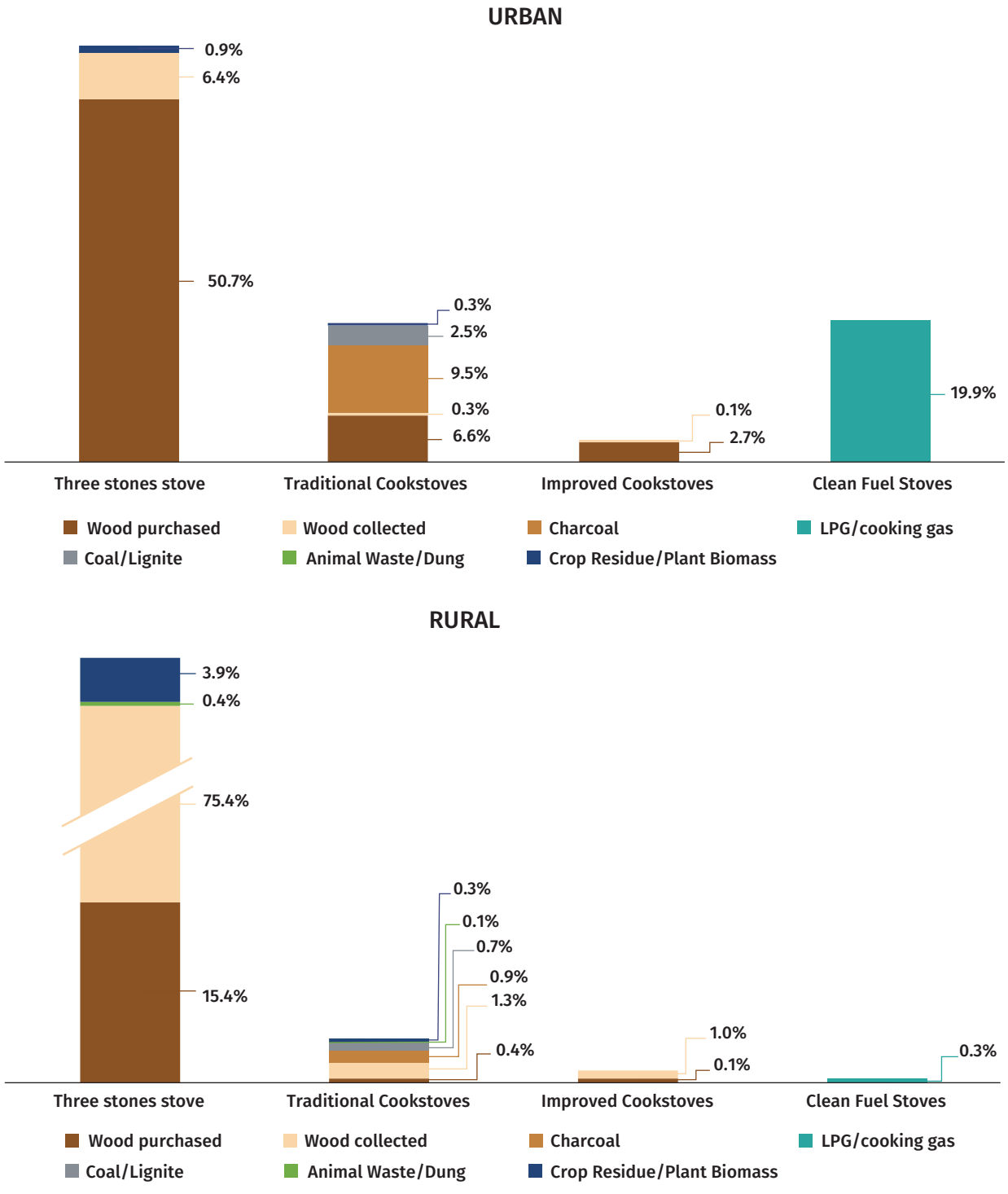


Note: LPG = liquefied petroleum gas.

Although three-stone stoves are the main cooking solution used in both urban and rural settings, urban and rural households have different cooking patterns (Figure 37). Urban households show a more diverse array of cooking technologies and rely less on biomass fuels. Urban households cook predominantly with firewood (66.7%), followed by LPG (19.9%) and charcoal (9.5%). Over half of urban households use a three-stone stove as their primary cooking solution (58.1%), followed

by clean fuel stoves (19.9%) and traditional stoves (19.2%). Improved cookstoves are only marginally used (2.8%). In rural areas, nearly all households cook with firewood (93.5%). Rural households use three-stone stoves almost exclusively to cook with biomass. Wood is mainly collected in rural settings and purchased in urban areas. Charcoal and LPG use is concentrated in urban settings. There is no significant pattern of stove stacking in Niger (1.4% of households).

FIGURE 37 • **Distribution of cookstoves and fuels used (urban/rural)**

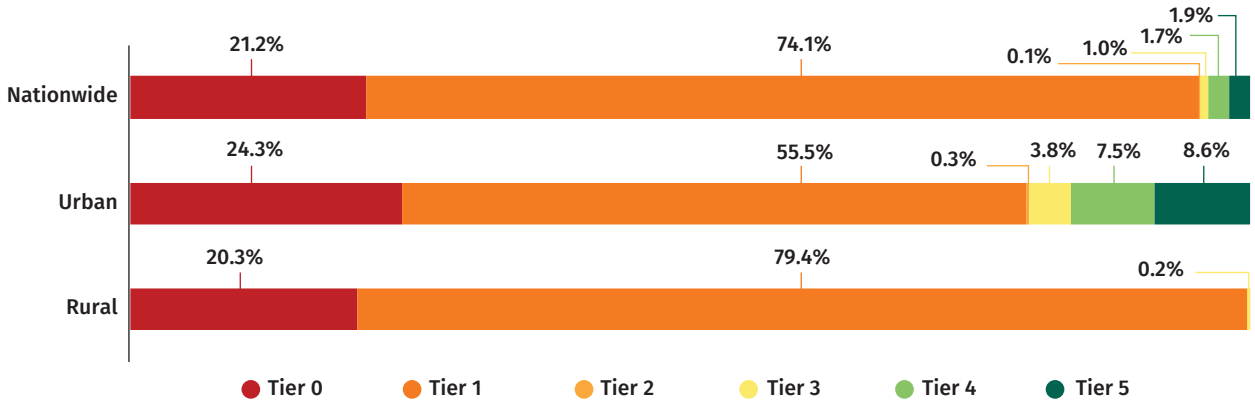


Note: LPG = liquefied petroleum gas.

MTF TIERS

About 95% of Niger households are in Tiers 0–1 for access to modern energy cooking solutions. Only 1.9% of households are in Tier 5 among the 4.7% that are in Tier 2 or above (Figure 38). A significant gap between urban and rural households has been identified in the MTF cooking tier distribution: all rural households are within Tiers 0–1 while 20% of urban households are within Tiers 2–5. Nearly 1 in 10 urban households is in Tier 5 for access to modern energy cooking solutions.

FIGURE 38 • **MTF tier distribution (nationwide, urban/rural)**

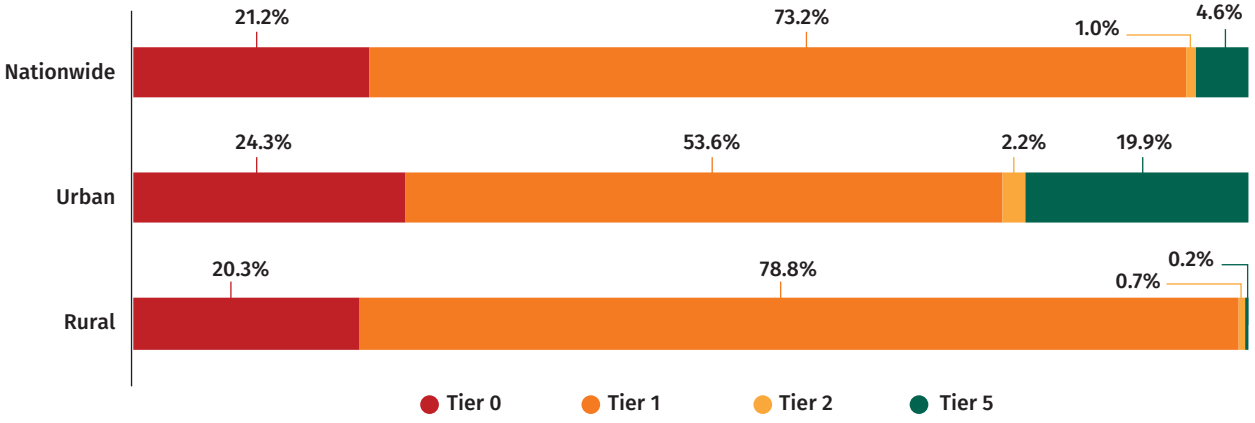


MTF ATTRIBUTES

Cooking Exposure

For the Cooking Exposure attribute, which represents an estimate of personal exposure during cooking activities based on emissions from cooking and its mitigation through ventilation,[19] nearly 95% of Niger households are in Tiers 0 and 1 (Figure 39). The Cooking Exposure Tier is negatively affected by the fact that 86.7% of households use biomass with three-stone stoves. Less than 1% of rural households are in Tiers 2–5 (0.9%) compared with 22% of urban households.

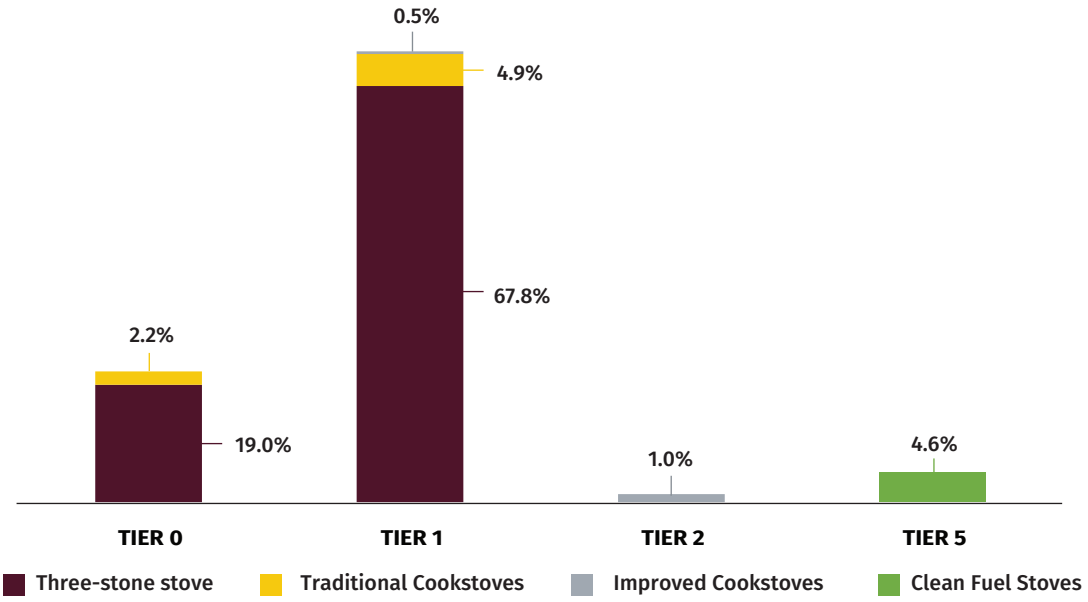
FIGURE 39 • **Tier distribution of Cooking Exposure (nationwide, urban/rural)**



[19] In this survey, the categorizations are based on typology of stoves, fuels, and their context of use, not on actual technical measurements.

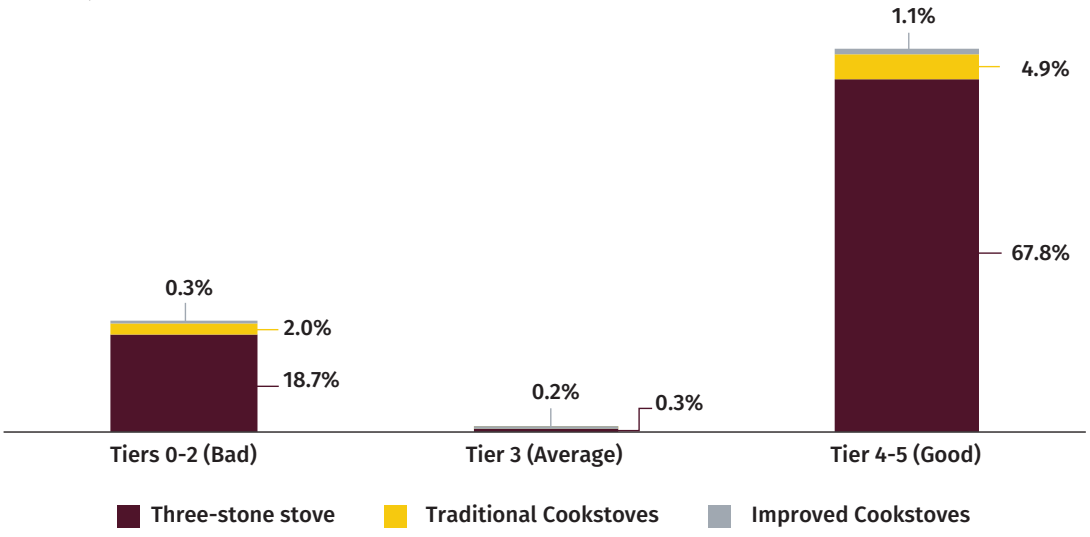
Households using three-stone stoves as their primary stoves account for the largest share of Tier 0 for the Cooking Exposure attribute. A large portion of primary stoves (67.8%) that are three-stone fire stoves reach Tier 1, because of their better ventilation. Households using an improved cookstove are classified between Tier 1 and Tier 2 for Cooking Exposure. Biomass stoves, however, do not achieve Tier 3 for exposure because of the absence of advanced biomass stoves, such as gasifier stoves, which could reduce pollutants significantly (Figure 40).

FIGURE 40 • **Distribution of households based on Cooking Exposure, by primary cookstove (nationwide)**



For ventilation, biomass fuel stoves mostly range from Tier 4 to Tier 5 and to a lesser extent from Tier 0 to Tier 2 (Figure 41). A large share of households cooking outdoors have relatively good ventilation. The bad ventilation tiers result from the many households that cook in small indoor spaces with no or few openings. The absence of Tier 4 in the ventilation structure indicates that households do not use chimneys in kitchens.

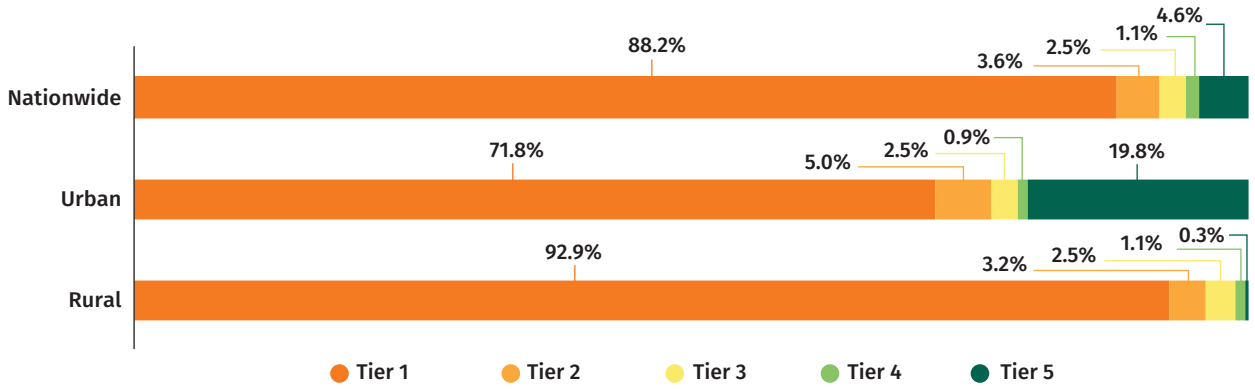
FIGURE 41 • **Distribution of households based on ventilation, by primary biomass cookstove (nationwide)**



Convenience

Convenience is determined by the time spent collecting and preparing fuel per week and preparing the stove for cooking. In Niger, 91.8% of households (Tier 1 and 2) spend more than 3 hours a week in fuel collection or at least 10 minutes per meal in stove preparation (Figure 42). Biomass users are overrepresented in the low Convenience Tiers, while all LPG users reach Tier 5 for Convenience.

FIGURE 42 • **Distribution of households based on Convenience (nationwide, urban/rural)**



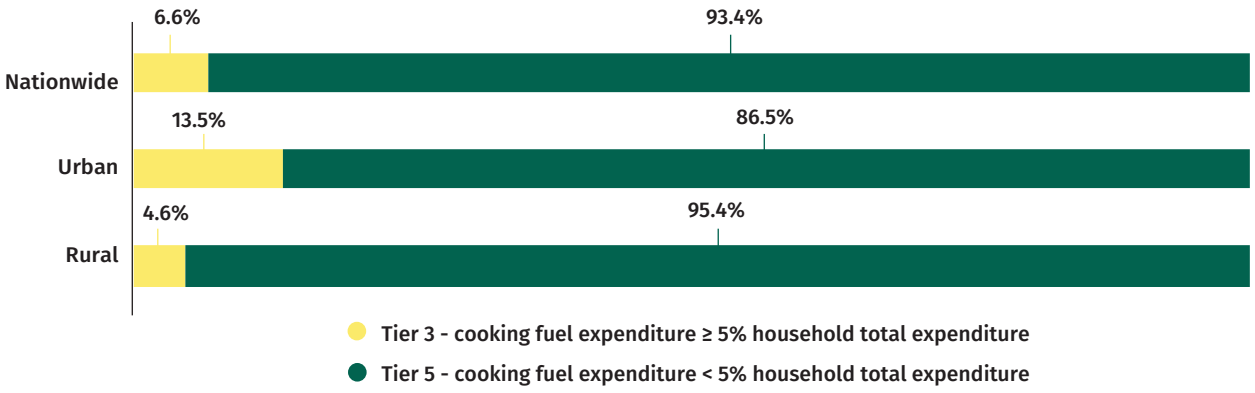
Safety of primary cookstove

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 is used to measure Safety. Over the years prior to the survey, if household members did not experience any accidents that required professional medical attention, then the cooking device was considered safe. This was the case for 99.5 % of households, which did not experience such accidents. All households that reported such accidents during the previous 12 months were using open fire stoves.

Affordability

Affordability 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 the household's monthly expenditure, the fuel is considered affordable. According to this criterion, 6.6% of households in Niger do not view their current cooking solution as affordable (Figure 43). A notable difference in Affordability was identified between rural and urban households. Affordability is a more pronounced problem in urban areas, while the vast majority of rural households collect fuelwood for free.

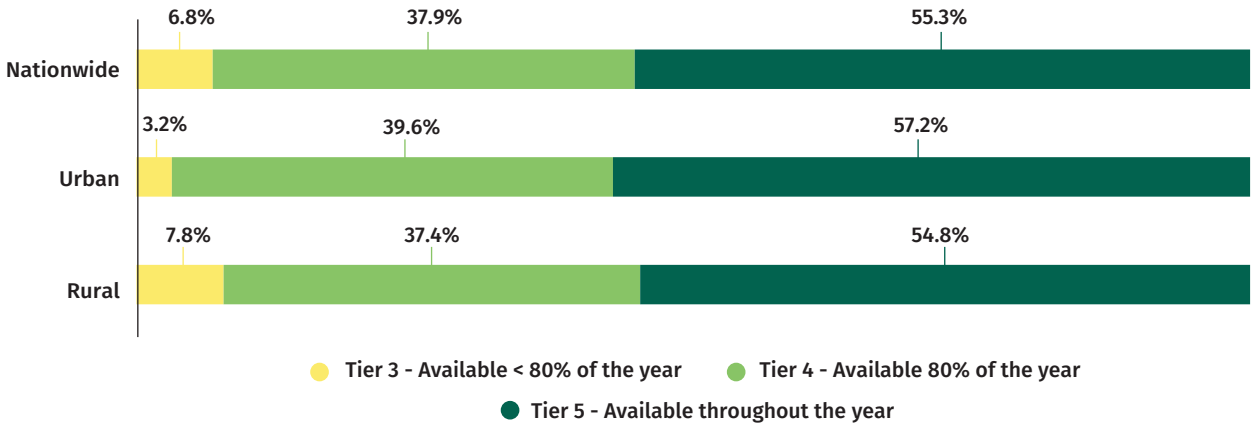
FIGURE 43 • **Distribution of households based on Affordability (nationwide, urban/rural)**



Fuel Availability

This attribute assesses the degree to which the fuel needed for a household's cooking purposes is available. Cooking fuel is available 80% of the year or less for close to half of Nigerien households (Figure 44).

FIGURE 44 • **Distribution of households based on Fuel Availability (nationwide, urban/rural)**

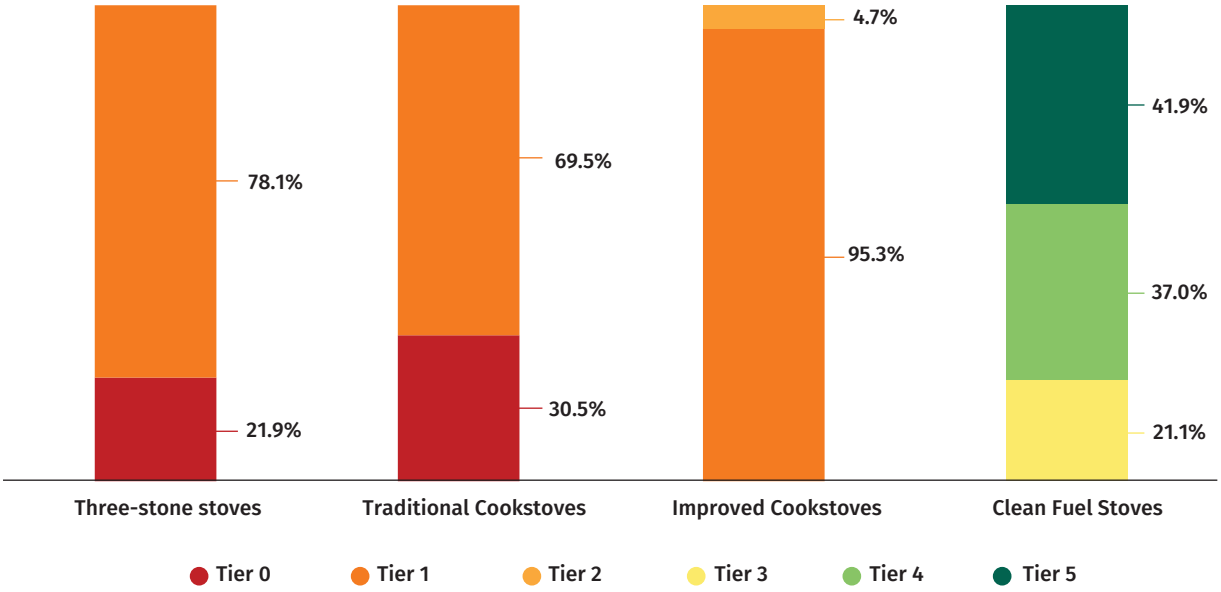


IMPROVING ACCESS TO MODERN ENERGY COOKING SOLUTIONS

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. In Niger, 94.4% of households are in Tiers 0–1 for access to cooking solutions, due to a heavy reliance on three-stone stoves that translates into poor performance on the Cooking Exposure attribute. An increase in the rate of adoption of clean fuel stoves could boost households to higher tiers. In addition, the introduction and promotion of improved cookstoves could help shift households, particularly Tier 0–1 households, to higher tiers.

Increase penetration of clean fuel stoves. The use of clean fuel stoves is limited in Niger, where 4.6% of households use LPG stoves as their main cooking solution at the national level. Clean fuel stoves tend to be in higher tiers (Figure 45). While three-stone and traditional stove users are located in Tiers 0–1, LPG stove users reach Tiers 3–5.

FIGURE 45 • **Tier distribution by stove technology (nationwide)**



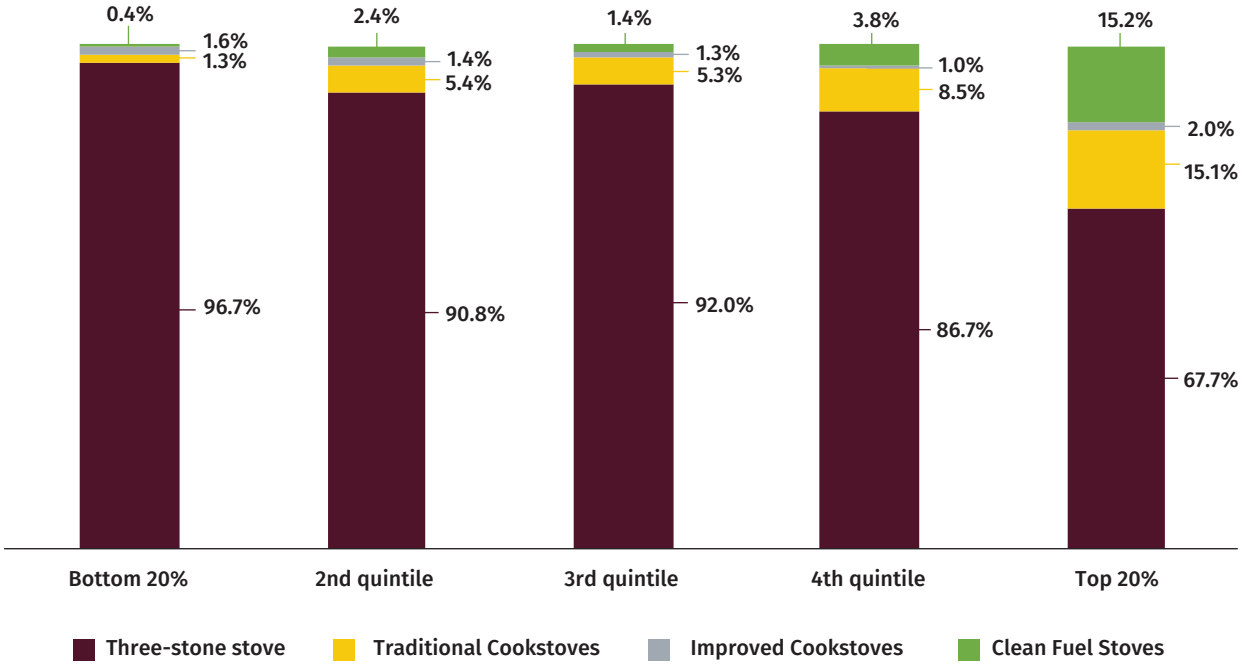
LPG is exclusively an urban cooking fuel, used by 19.9% of households in this setting and mostly in three urban centers (Niamey, Agadez, and Diffa). This finding suggests that the infrastructure may not be readily available for households to acquire and replace their cylinders across all regions of the country, particularly in rural areas where this fuel has yet to enter the market. Since LPG is available less than 80% of the year, 41.7% of households currently using an LPG stove as their main cookstove already experience Availability issues. LPG consumed in Niger is currently produced nationally by SORAZ (Société de Raffinage de Zinder) as a by-product, and it is expected that current production capacity will be surpassed by demand very soon. The promotion of LPG would most likely require coordinated government support to facilitate a stable and sustainable fuel supply.

Affordability of LPG may also be an issue, particularly for households in the lower expenditure quintiles, which are disproportionately common in rural areas (Figure 1).

Clean fuel stoves are used to only a marginal degree by households below the top 20% quintile for household expenditure (Figure 46). At the time of the survey, the cost of acquiring a cooking gas stove was CFAF 25,000 (US$47.70), while bottom-of-the-range traditional cookstoves started at CFAF 550 (US$1) and improved cookstoves at CFAF 750 (US$1.40).

Efforts to promote LPG cookstoves would need to ensure that any potential Availability, Affordability, Convenience, and Safety issues are being adequately addressed, to increase the share of clean fuel users. The Availability of affordable LPG stoves and campaigns promoting awareness of the benefits of clean fuels will help increase the adoption of LPG stoves.

FIGURE 46 • **Main stoves used, by expenditure quintile (nationwide)**



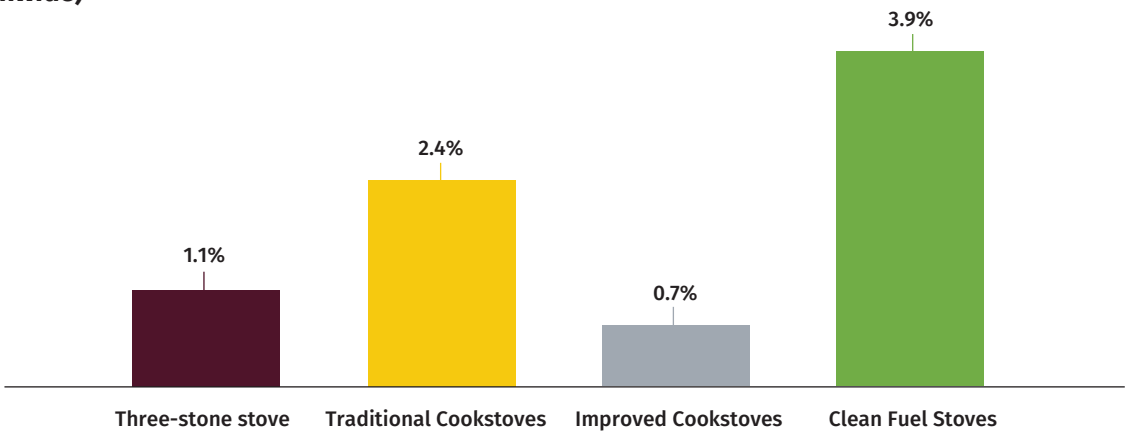
Introduce and promote the use of improved cookstoves as the primary cooking solution. Introducing and promoting the use of improved cookstoves is the most feasible and immediate solution for households that use three-stone or traditional stoves, particularly rural households among which switching to clean fuel stoves (LPG) is not feasible because fuel is not available or affordable. Among rural households, 98.6% use three-stone stoves (95%) or traditional stoves (3.6%) as their main stove. Virtually all of these rely on wood for cooking and are in Tier 0 or 1, mainly because of the Cooking Exposure and Convenience attributes.

In Niger, improved cookstoves cannot be found on the market. Only remnants of previous household energy programs, such as Maisauki stoves for burning firewood, are still in use. Biomass is the main fuel for 93.8% of households in the country, and firewood in particular is used by 87.5% of households. In the absence of improved cookstoves burning firewood currently produced or sold in Niger, it was not possible to test households' willingness to pay for low-emission, cleaner, and more efficient devices.

The potential benefit of switching to an improved cookstove is not as significant as in the case of clean fuels, but it is still substantial, particularly because of greater energy efficiency and a reduction in expenditures on fuel and in the time spent obtaining fuel. The latter is especially true for the 77.7% of rural households relying predominantly on collected wood for cooking. Indeed, households that switch from three-stone stoves or traditional stoves to an improved cookstove will save on the time spent collecting fuel. Households cooking with three-stone or traditional stoves currently spend an average of 11.3 hours and 13.1 hours a week, respectively, on obtaining cooking fuel. Users of improved cookstoves spend an average of 9.1 hours per week.

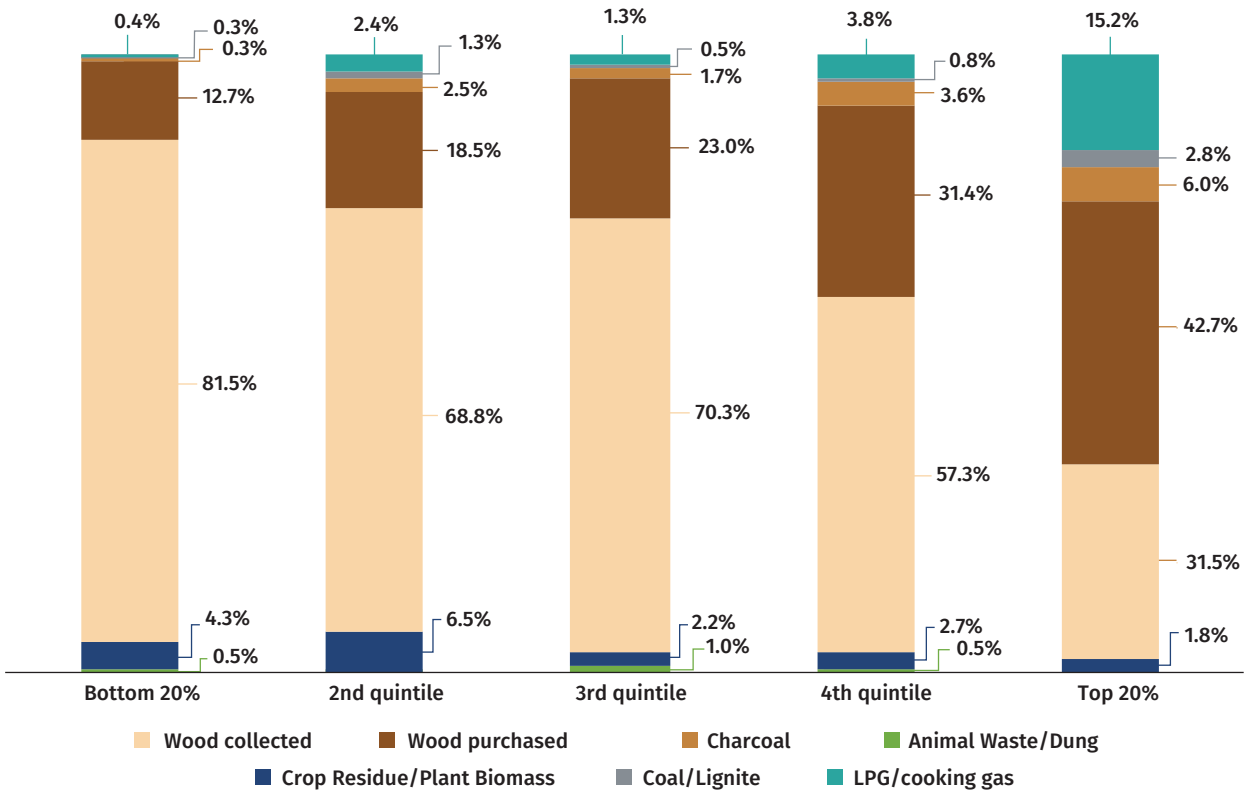
Among biomass users, households relying on improved cookstoves spend a smaller share of their budget on fuels for cooking (Figure 47), making this technology attractive for households who buy fuelwood.

FIGURE 47 • **Average share of household expenditure on cooking fuel by stove technology (nationwide)**



Considering the relative failure of previous household energy programs in the country and in order to propose improved woodstoves that could be adopted and bring added value to households in Niger, the needs and preferences of these households would need to be thoroughly assessed in the first place. This would entail conducting a detailed analysis of current fuel use, stove use, and cooking practices of wood fuel users and assessing their willingness to pay for improved cooking devices. This is especially true for the significant share of households that collect wood for cooking on three-stone stoves at no cost (60%). The average monthly expenditure is generally lower among households that use biomass as their main cooking fuel than of households using LPG. Purchasing an improved cookstove at the full up-front cost may thus be financially burdensome for households relying on biomass (Figure 48).

FIGURE 48 • **Main fuel distribution by expenditure quintile (nationwide)**



Note: LPG = liquefied petroleum gas.

The key factors that might motivate a switch to improved cookstoves need to be determined in order to promote a range of adequate and sustainable options in the country, be they locally manufactured or imported. Raising public awareness regarding the positive health, social, and environmental impacts of switching to improved cookstoves is key to ultimately fostering their adoption.

POLICY RECOMMENDATIONS

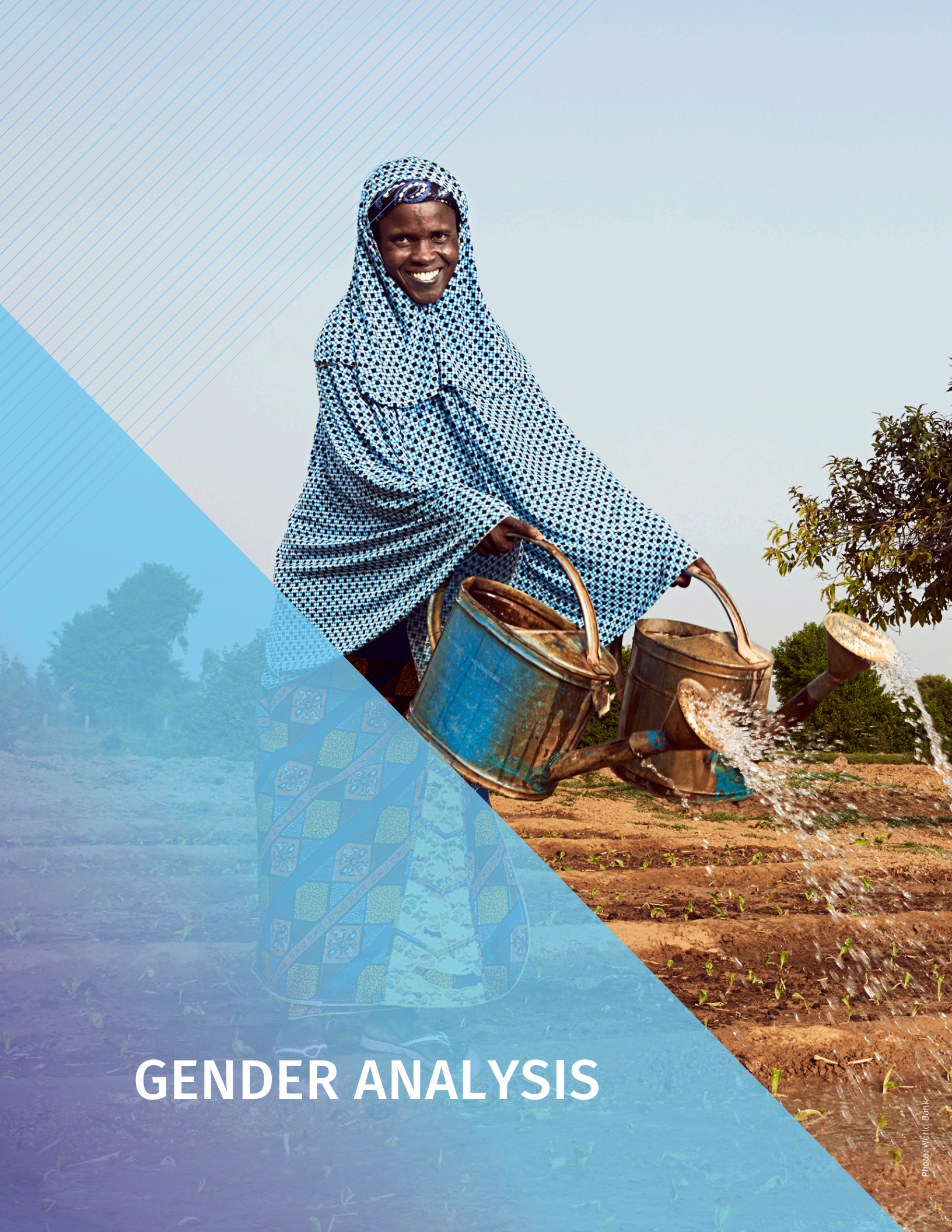
In Niger, 94.4% of households are in Tier 0 to 1 for access to cooking solutions. In order to shift these households to higher tiers, switching to clean fuel stoves would be critical, especially for those who can readily afford and acquire these stoves and related fuels.

- **Increase penetration of clean fuel stoves (LPG stoves):** The use of LPG stoves can substantially reduce the emission of indoor air pollutants and shift households to higher tiers of access (LPG stove users in Niger enjoy access at Tiers 3–5). The wider adoption of these stoves might therefore be worth encouraging, especially in urban areas. 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 could be devised that covers both the supply and the demand side, including awareness-raising campaigns.

- **Switch to improved biomass stoves:** 93.9% of households primarily use three-stone or traditional biomass stoves in Niger. The majority of these households relying on wood for cooking are in Tier 0 or 1, mainly because of problems of Cooking Exposure (personal exposure to pollutants from cooking activities) and Convenience. In order to shift these households to higher tiers, switching to improved biomass stoves would be key among households that cannot afford clean fuels or do not have clean fuel options available.

- **Promote improved biomass stoves:** No improved woodstoves currently exist in the country. A thorough demand-side analysis of household needs, preferences, and willingness to pay for improved cookstoves needs to be conducted, as well as a campaign to raise public awareness before introducing a range of adequate and sustainable biomass-based improved cookstoves in the country. These efforts might be best supported by offering a longer payment period or reducing the up-front cost of improved biomass stoves. Users of biomass fuels are indeed poorer than non-solid-fuel users in the country.

More than 8 out of 10 households in Niger (81.6%) lack both access to the grid and access to improved cookstoves that utilize biomass as a primary fuel. This share reaches 91.6% of households in rural areas. Synergies can be found in providing public support to distributors that could deliver both solar products and improved cookstoves to this segment, improving access to electricity as well as access to modern energy cooking solutions while reducing the cost of serving these households.

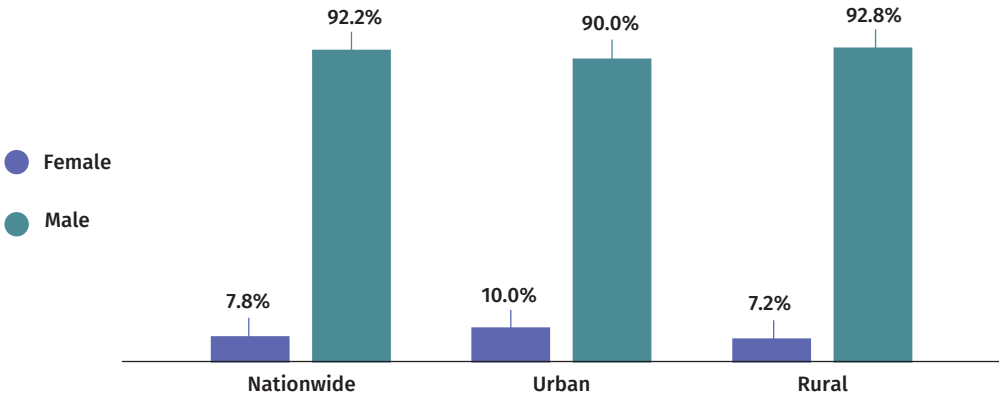


GENDER ANALYSIS

Photo: World Bank

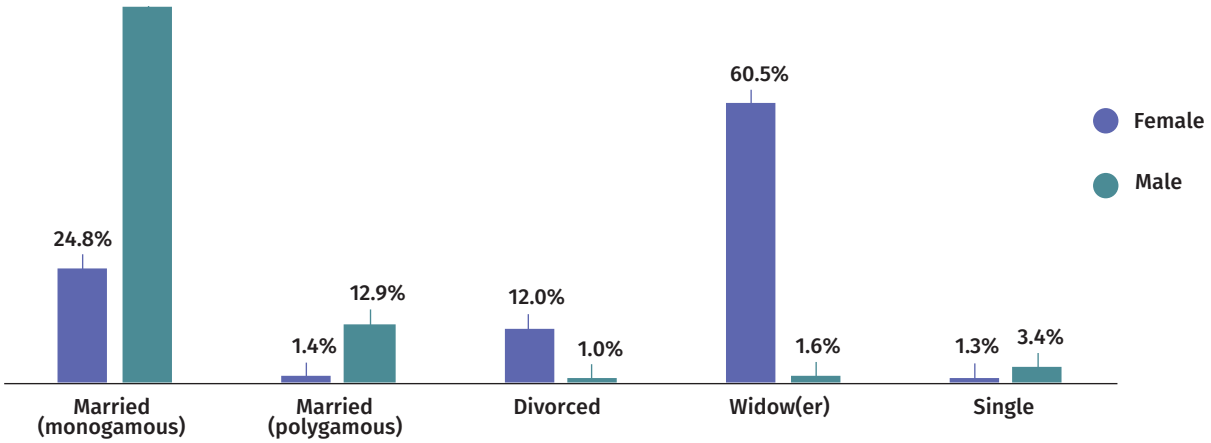
About 7.8% of households in Niger are headed by women (Figure 49). The share is slightly larger in urban than rural areas. Female-headed households have on average 3.6 members, against 5.2 members for male-headed households.

FIGURE 49 • **Distribution of households by sex of the household head (nationwide, urban/rural)**



About 6 in 10 female heads are widows, compared with only 1.6% of male heads (Figure 50). Most male heads are married: about 8 in 10 are in monogamous marriages and 1 in 10 is in a polygamous marriage. Only 1 in 4 female heads are married. Nationwide, female heads are on average about 5 years older than male heads (47.7 versus 42.4). In urban areas, female heads are almost 8 years older than male heads (49.8 versus 42.1).

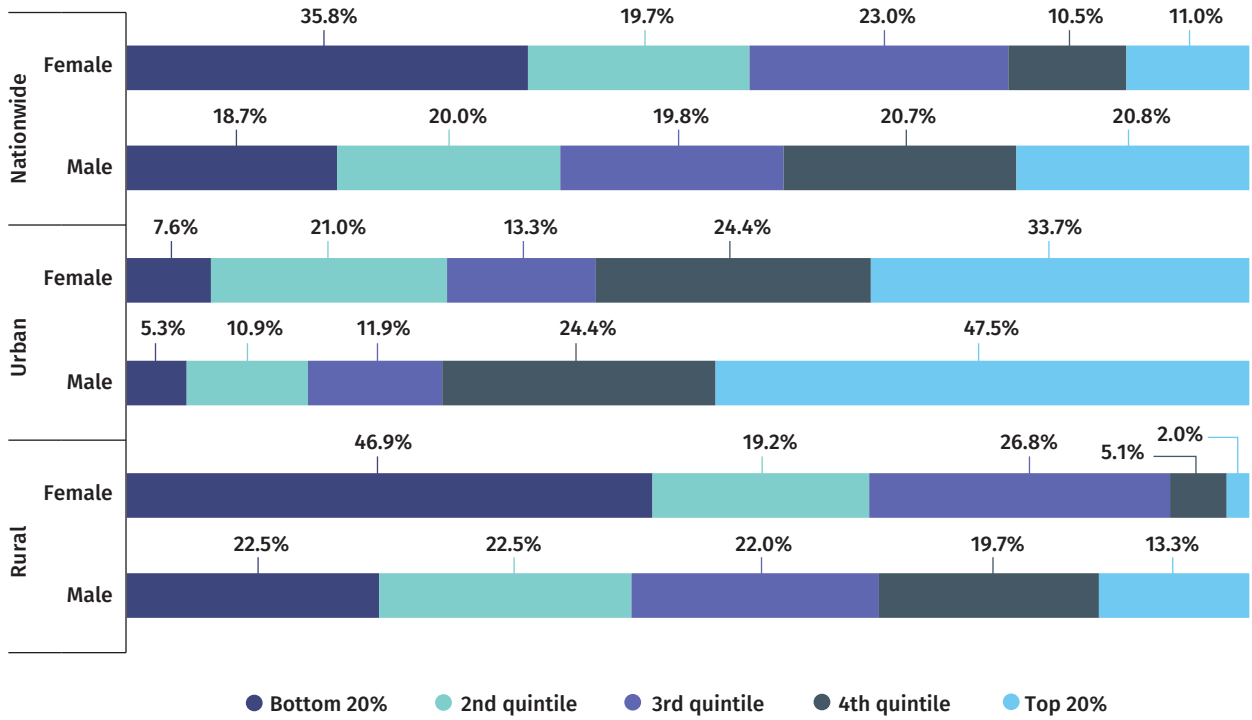
FIGURE 50 • **Marital status of the household head, by sex (nationwide)**



The large majority of male and female heads have never attended school (83.8% of female heads and 79.1% of male heads). The rest have attended school but dropped out (15.9% of female heads and 20.4% of male heads). Male heads have been schooled for 1 more year on average than female heads (8.6 years versus 7.7 years). Only 2 in 10 female heads work, against over 9 in 10 male heads. Working women either own a non-farm business (7%) or are self-employed in the agricultural sector (6.8%). On the other hand, over half of the male heads are self-employed in the agricultural sector, 16.4% are casual laborers, and 11.3% own a non-farm business.

Female-headed households tend to be poorer than male-headed households, particularly in rural areas (Figure 51). Nationwide, 35.8% of female-headed households are in the bottom quintile, against 18.7% of male-headed households. The gap increases in rural areas, with 46.9% of female-headed households falling in the poorest quintile, versus 22.5% of male-headed households. Female-headed households are also underrepresented in the top quintile (11% versus 20.8% nationwide). Also, the average monthly household expenditure for female-headed households is about 30% lower compared with male-headed households (CFAF 44,436 versus CFAF 65,247).

FIGURE 51 • **Distribution of male- and female-headed households by household expenditure quintile (nationwide, urban/rural)**



Female heads are less likely to have access to finance than male heads (73.5% versus 78.6%) (Figure 52). The gender gap in access to finance tends to be wider in rural areas. It is worth noting that the main source of finance is relatives, friends, or neighbors, followed by stores. Only 3.1% of female heads and 3.5% of male heads have access to finance from a formal institution.[20]

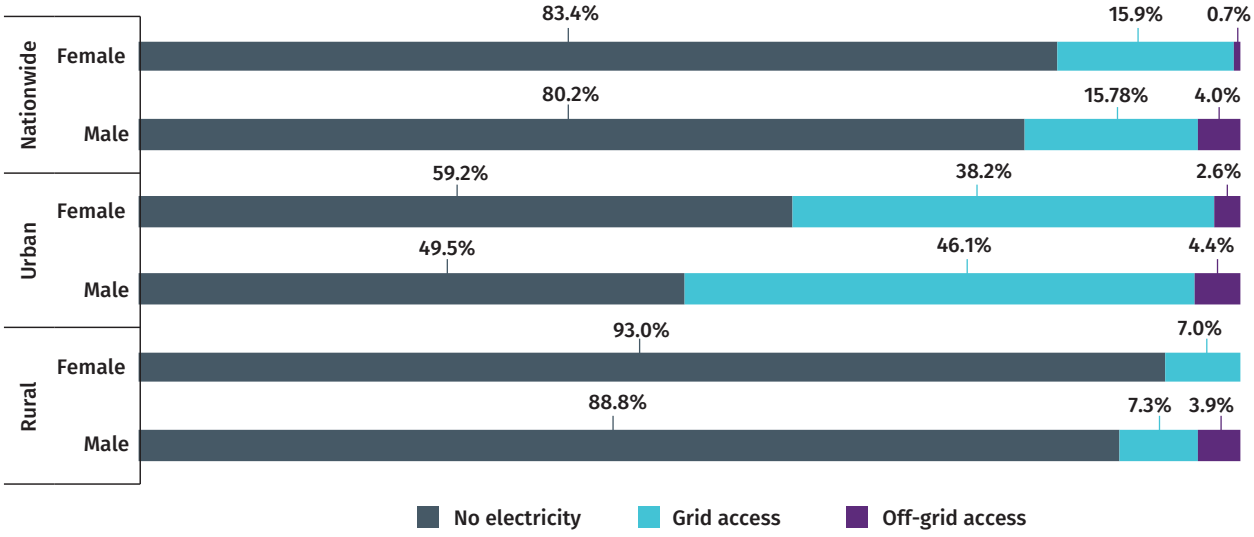
[20] Formal institutions include commercial/government banks, cooperative credit unions, micro-finance institutions, the state, and non-governmental organizations.

FIGURE 52 • **Access to finance (loan/credit) by sex of the head of household (nationwide, urban/rural)**

ACCESS TO ELECTRICITY

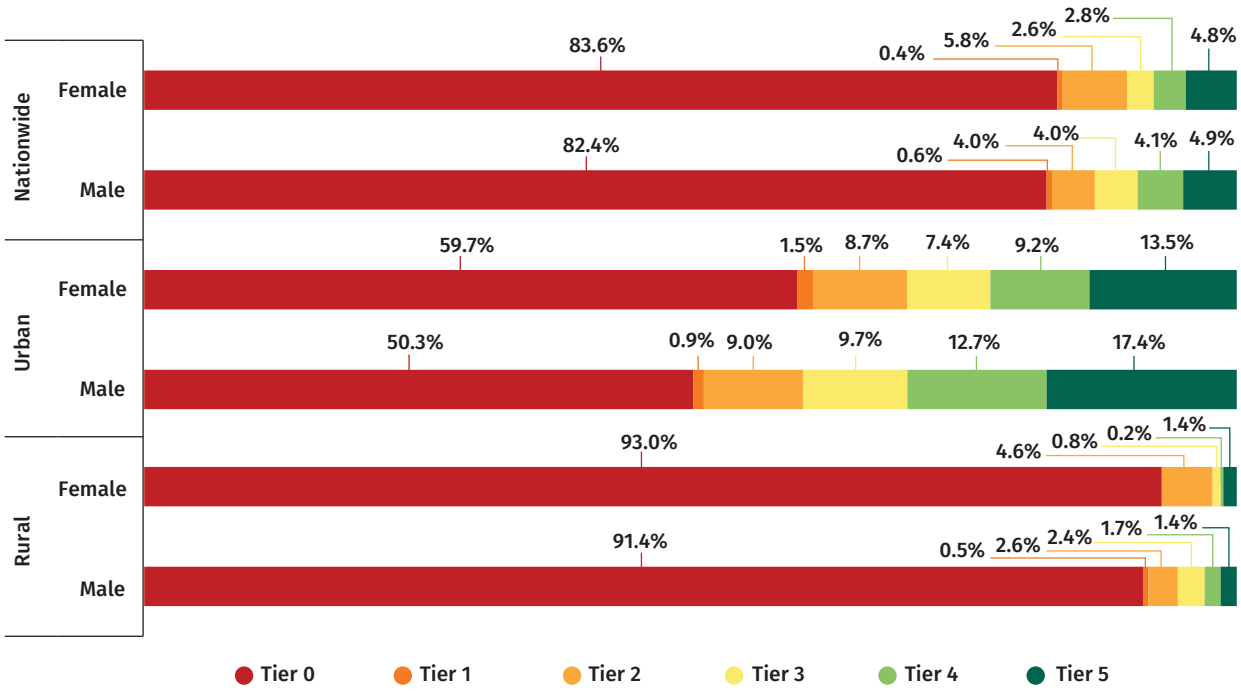
Nationwide, male-headed households are slightly more likely to have access to electricity than female-headed households (19.8% versus 16.5%) (Figure 53). Female-headed households are less likely to have access to grid electricity in urban areas compared with male-headed households (38.2% versus 46.1%). In rural areas, grid access rates are similar for both groups. Access to off-grid solutions is higher for male-headed households than female-headed households (4% versus 0.7%). It is negligible for the latter and concentrated in urban contexts.

FIGURE 53 • **Access to electricity, by technology and by sex of the household head (nationwide, urban/rural)**



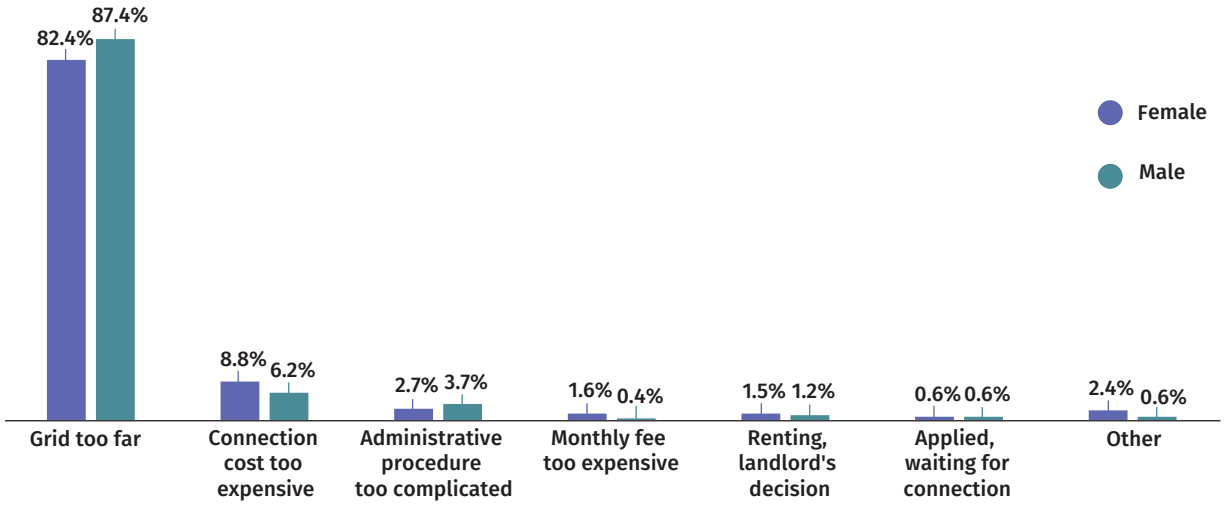
Female-headed households are slightly more likely to fall in Tier 0 than are male-headed households (83.6% versus 82.4%), in line with their lower electricity access rate. In urban areas, 59.7% of female-headed households fall in Tier 0, compared with 50.3% of male-headed households, given that female-headed households are less likely to have access to (grid) electricity in urban areas compared with male-headed households (Figure 54). For this reason, urban female-headed households are also less likely to reach Tiers 4 and 5 for access (22.7% versus 30.1%).

FIGURE 54 • **MTF electricity tier distribution, by sex of the household head (nationwide, urban/rural)**



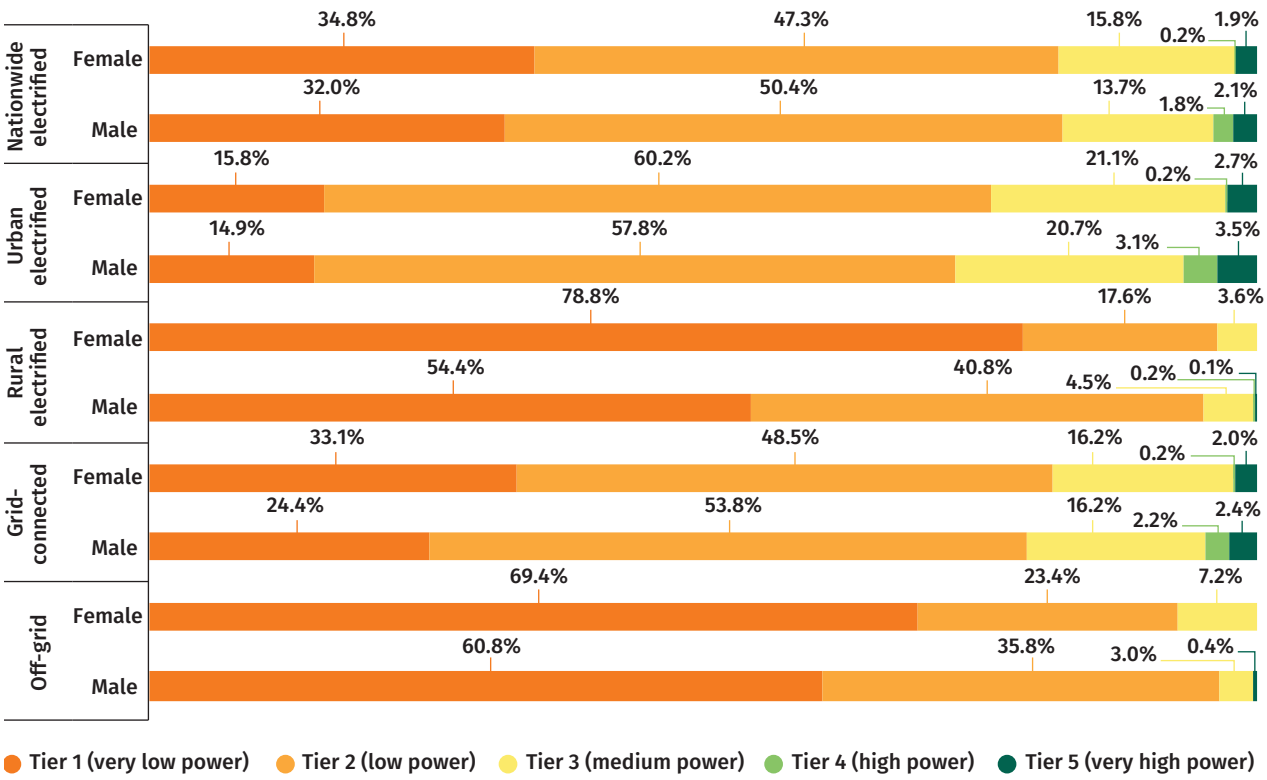
For both female- and male-headed households, the main reason for not being connected to the grid is that the grid is too far away or not available (82.4% and 87.4%, respectively) (Figure 55). This is equally an issue for female- and male-headed households in rural areas. However, it is more likely that female-headed households will be unable to pay for the connection cost, compared with their male counterparts (8.8% versus 6.2%). This is especially true in urban areas, where 31.7% of female-headed households reported the connection cost as the main issue, compared with 23.6% of male-headed households.

FIGURE 55 • **Barriers to gaining access to the electricity grid, by sex of the household head (nationwide)**



Nationwide, female-headed households are slightly less likely than male-headed households to own appliances other than very low load ones (Figure 56). However, the gap widens in rural areas. The rates of ownership for all types of appliance are systematically lower for female-headed households compared with male-headed households.[21] The largest gap is reported for mobile phone chargers (28.7% for female-headed households versus 42.5% for male-headed households).

FIGURE 56 • **Ownership of appliances by load level, by gender of the household head (nationwide, urban/rural, grid/off-grid access)**

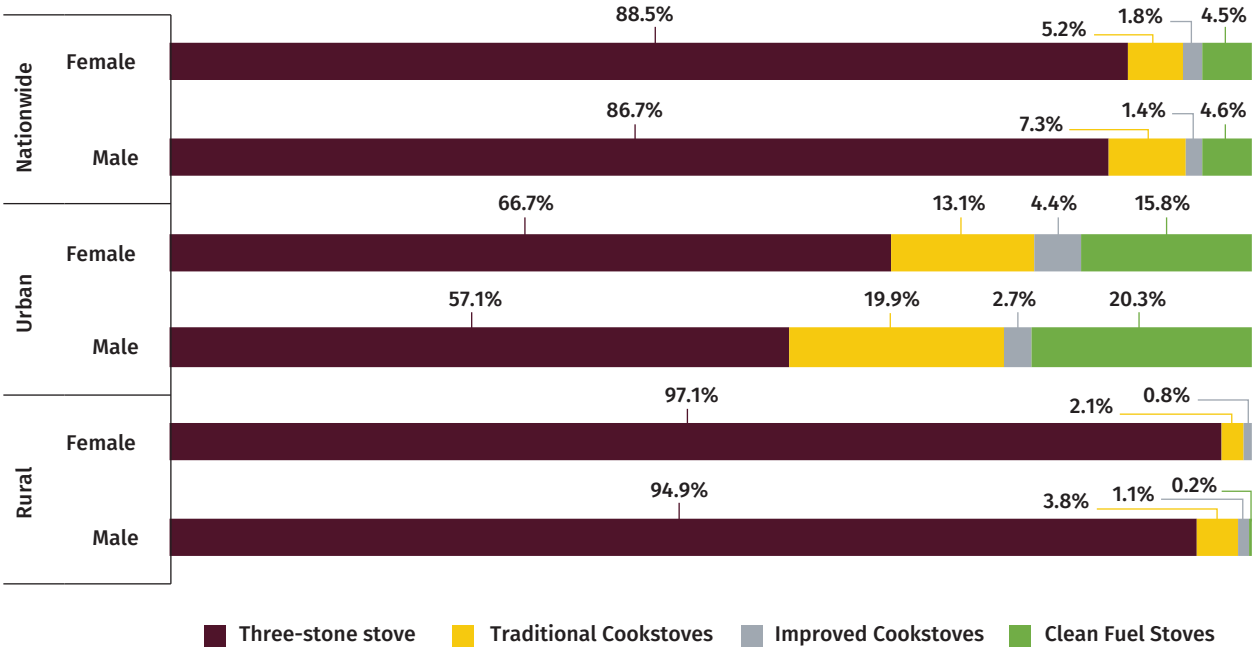


[21] The only exceptions are appliances that can be powered with dry-cell batteries (such as torches, flashlights, and rechargeable lanterns).

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

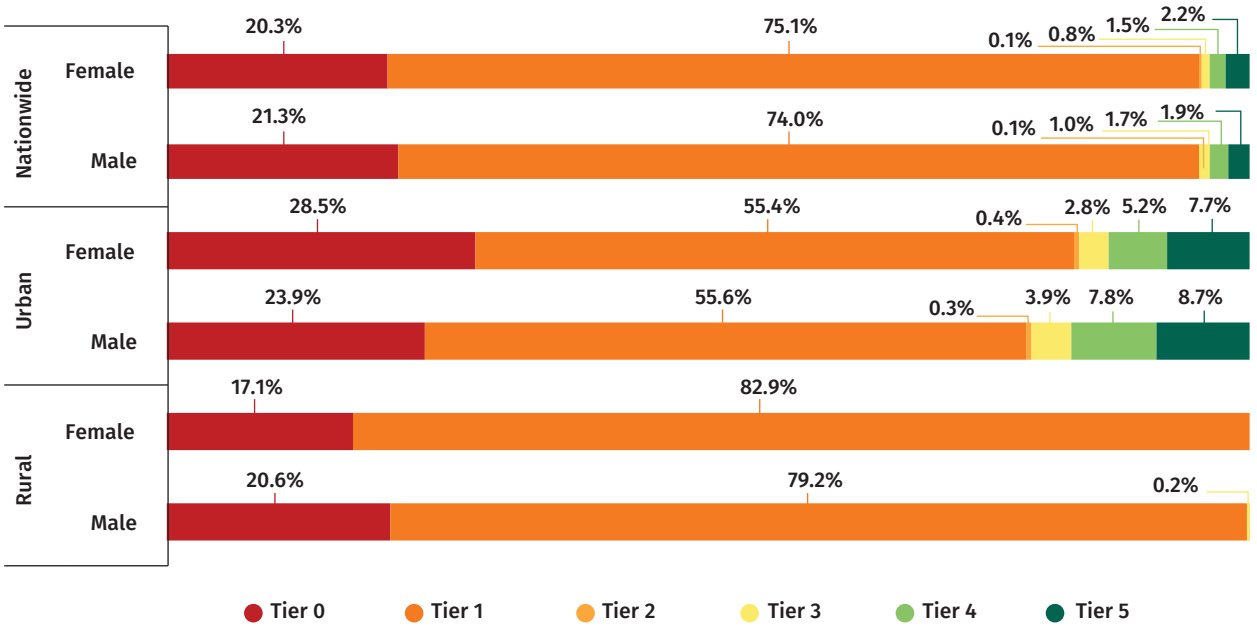
Nationwide, female-headed households are slightly more likely to use three-stone stoves and less likely to use traditional stoves compared with male-headed households, while there is no gender gap in the use of liquefied petroleum gas (LPG) stoves (Figure 57). In urban areas though, female-headed households tend to have less access to improved stoves and LPG stoves.

FIGURE 57 • **Access to cooking solutions, by type of primary cookstove and by sex of the household head (nationwide, urban/rural)**



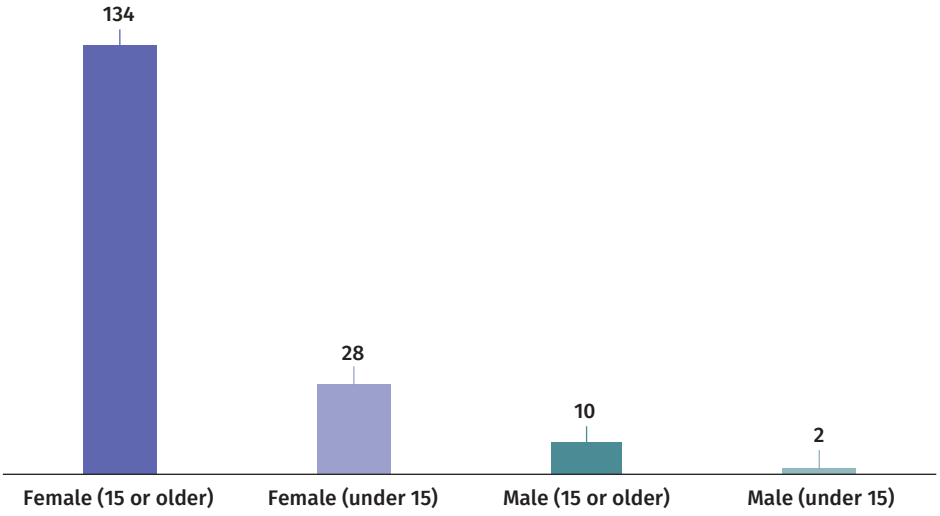
Nationwide, the Multi-Tier Framework (MTF) cooking tier distribution shows overall fairly small gaps between female- and male-headed households (Figure 58). In urban areas, female-headed households are more likely to fall in Tier 0 (28.5% versus 23.9%) and slightly less likely to reach Tier 4 and Tier 5 access (12.9% versus 16.5%), compared with male-headed households. In rural areas, although female-headed households are more likely to use a three-stone stove, they are slightly less likely to be in Tier 0 (17.1% versus 20.6%), compared with male-headed households. This is mainly due to the fact that female-headed households cooking with three-stone stoves have better ventilation than male-headed households cooking with three-stone stoves.

FIGURE 58 • **MTF cooking tier distribution, by sex of the household head (nationwide, urban/rural)**



Women (aged 15 or older) spend much more time cooking (2 hours and 14 minutes per day) than girls (28 minutes), men (10 minutes), and boys (2 minutes) (Figure 59).

FIGURE 59 • **Time spent on cooking (minutes per day) by sex and age of household members (nationwide)**



Nationwide, girls (under 15) and boys (under 15) spend significantly more time preparing fuels[22] than women (aged 15 or older) or men (aged 15 or older). While girls and boys respectively dedicate an average of 4.2 hours and 3.7 hours a week, women spend 2.4 hours and men a mere 0.7 hours a week on fuel preparation (Figure 60). Fuel preparation takes longer across all gender and age groups in rural areas. Girls spend about 30 minutes per week more than boys, on average, and women spend 1.7 hours more per week than men. Households using clean fuel stoves tend to spend much less time preparing fuel than households cooking with other types of stoves.

[22] Not including fuel collection.

FIGURE 60 • **Time spent on fuel preparation (hours per week), by sex and age of household members (nationwide, urban/rural)**

POLICY RECOMMENDATIONS

Female-headed households appear to be more financially and socially vulnerable than male-headed households as they tend to be poorer, less educated, and less likely to have a job and access to credit. Also, over half of women heads of households are widows.

While female-headed households are slightly less likely to have access to electricity and less likely to have a grid connection in urban areas, further research should be carried out to identify their needs and priorities and possible ways to overcome barriers to energy access. Several pro-poor targeting actions, whereby female-headed households may be automatically eligible, may be considered, including interest-free credit for the purchase of energy equipment, credit schemes allowing payment of connection fees in affordable installments, subsidized connection costs, and lifeline tariffs. Considering the chronic energy poverty situation in Niger, this would also apply to vulnerable male-headed households.

Female-headed households are slightly more likely to use three-stone stoves and less likely to use traditional stoves compared with male-headed households, while there is no gender gap in the use of LPG stoves. In urban areas, female-headed households tend to have less access to LPG stoves than their male counterparts. However, women and girls in Niger (across both female- and male-headed households) spend much more time cooking than do men and boys. They are thus much more likely to be affected by indoor air pollution. Access to cleaner cooking solutions will therefore benefit women and girls more than men and boys. Girls and boys spend several hours per week just preparing fuel, and access to clean fuel stoves tends to dramatically reduce the time required.

It is recommended that cultural and gender roles be considered when designing solutions to increase access to modern energy cooking solutions. Relevant information might be gathered around culinary traditions, fuel preference and consumption levels, as well as fuel acquisition methods. Barriers to accessing clean fuels and modern energy cooking technologies should also be taken into account. Affordability constraints affecting poor households and female-headed households, for example, might be addressed through targeted financing mechanisms. Education campaigns are also recommended to raise awareness of the benefits of clean and efficient cooking solutions targeting both men and women.

ANNEX 1.
MULTI-TIER FRAMEWORK

TABLE A1.1 • **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	Min 4 hrs		Min 8 hrs	Min 16 hrs	≥23 hrs
	Evening	< 1 hr	Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	
Reliability	(Frequency of disruptions per week)	> 14				4–14	≤ 3
	(Duration of disruptions per week)					> 2 hrs (if frequency ≤ 3)	≤ 2 hrs
Quality (voltage problems affect the use of desired appliances)		Yes				No	
Affordability (cost of a standard consumption package of 365 kWh/year)		≥ 5% of household expenditure (income)			< 5% of household expenditure (income)		
Formality (bill is paid to the utility, pre-paid card seller, or 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 A1.2 • 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)[a]** PM2.5 (mg/MJd) CO (g/MJd)	>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 than 80% of the year				Available 80% of year	Readily available throughout the year

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

ANNEX 2.
SAMPLING STRATEGY

SAMPLE FRAME AND SAMPLE SELECTION PROCEDURE

The household survey sample selection was based on a stratified household sampling by region and urban/rural strata and connection/no connection to the national electric grid, aimed at achieving nationally representative samples. A two-degree sample selection was applied. The first degree corresponds to the enumeration area (EA) selection. For each region, the sampling frame used was the exhaustive list of all EAs from the latest population census dating from 2012 (4ème Recensement Général de la Population et de l'Habitat, RGP/H-2012). The sampling frame comprised 19,838 EAs. Each EA entails the following information: region, department, ID code, number of households, total population, and settlement type. The borders for each EA are clearly identified on maps especially created for the RGP/H-2012. The procedure to draw the survey sample is a stratified two-degree sample. The first degree sample was drawn independently in each strata (region and type of residency: urban/rural) with a probability proportional to the size of the EA (number of households).

The formula to calculate the sample size is:

$$n = \frac{z^2 r(1-r) f k}{e^2} = \frac{z^2 r(1-r)[1+\rho(m-1)]k}{e^2}$$

where:

n = Sample size in terms of number of households to be selected.

z = z-statistics corresponding to the level of confidence desired. The commonly used level of confidence is 95% for which z is 1.96.

r = Estimate of the indicator of interest to be measured by the survey.

f = Sample design effect. This represents how much larger the squared standard error of a two-stage sample is when compared with the squared standard error of a simple random sample of the same size. Its default value 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 (1) and is defined as: f = 1 + ρ (m – 1).

ρ = Intra-cluster correlation coefficient. This is a number that measures the tendency of households within the same Primary Sampling Unit (PSU) to behave alike with regards to the variable of interest. ρ is almost always positive, normally ranging from 0 (no intra-cluster correlation) to 1 (when all households in the same PSU are exactly alike). For many variables of interest in the Living Standards Measurement Study (LSMS) household surveys, ρ ranges from 0.01 to 0.10, but it can be 0.5 or larger for infrastructure related variables.

m = Average number of households selected per PSU.

k = Factor accounting for non-response. Households are not selected using replacement.[23] Thus, the final number of households interviewed will be slightly less that the original sample size eligible for interviewing. For most developing countries, the non-response rate is typically 10% or less. So, a value of 1.1 (= 1 + 10%) for k would be conservative.

e = Margin of error, sampling errors, or level of precision. These depend to a large degree on the size of the sample, and very little on the size of the population.

ESMAP–World Bank calculated a sample size of 4,128 households to be drawn from 344 EAs. Thus, EAs are drawn in the first degree. For each region, the sampling frame consists of an exhaustive list of all EAs from RGP/H-2012. Since each region has a different size in terms of population, and hence number of households and number of EAs, the sample will be proportional to the size of each region. So, the first degree sample will be drawn independently in each strata. The total number of 344 EAs are randomly drawn proportionate to the size of the EA (number of households) and its electrification status. The EAs are spread over the whole national territory, of which 138 are in urban areas and 139 in rural areas. An additional sample of 67 urban EAs is drawn independent of their electrification status.

TABLE A2.1 • **Breakdown of sample enumeration areas by region, urban/rural, and electrification status**

Region	Urban		Rural		Total
	With electricity	Without electricity	With electricity	Without electricity	
Agadez	7	4	2	2	15
Diffa	3	2	0	0	5
Dosso	5	4	10	7	26
Maradi	11	8	16	10	45
Niamey	31	20	0	1	52
Tahoua	10	6	20	13	49
Tillaberi	5	3	13	9	30
Zinder	11	8	22	14	55
Total	**83**	**55**	**83**	**56**	**277**

LISTING AND SECOND-DEGREE SELECTION

Each EA that is selected in the first degree is subject to an exhaustive listing (without omission or double count) thanks to a listing form used to find out the total number of households living in a locality, be they connected or not to the national grid. Twelve households are then systematically selected with equal probability. So, within those 344 EAs, 4,128 households are interviewed in total, of which 2,460 are in urban areas (including 804 additional households in the 7 main cities excluding Diffa) and 1,668 in rural areas. The 12 households selected in each EA will be surveyed.

[23] The sample size should be calculated to reflect experience in the country in question. Hence, certain households may be replaced in particular countries if needed. In this case, a different weight will be considered when preparing the estimates.

TABLE A2.2 • **Breakdown of sample urban households by region and electrification status**

Region	Urban					
	EAs with electricity (3/5)			EAs without electricity (2/5)		
	Number of EAs	Number of connected households	Number of unconnected households	Number of EAs	Number of unconnected households	Additional households
Agadez	7	70	14	4	48	72
Diffa	3	30	6	2	24	0
Dosso	5	50	10	4	48	48
Maradi	11	110	22	8	96	120
Niamey	31	310	62	20	240	300
Tahoua	10	100	20	6	72	96
Tillaberi	5	50	10	3	36	48
Zinder	11	110	22	8	96	120
Total	**83**	**830**	**166**	**55**	**660**	**804**

Note: EA = enumeration area.

TABLE A2.3 • **Breakdown of sample rural households by region and electrification status**

Region	Rural				
	EAs with electricity (3/5)			EAs without electricity (2/5)	
	Number of EAs	Number of connected households	Number of unconnected households	Number of EAs	Number of unconnected households
Agadez	2	20	4	2	24
Diffa	0	0	0	0	0
Dosso	10	100	20	7	84
Maradi	16	160	32	10	120
Niamey	0	0	0	1	12
Tahoua	20	200	40	13	156
Tillaberi	13	130	26	9	108
Zinder	22	220	44	14	168
Total	**83**	**830**	**166**	**56**	**672**

Note: EA = enumeration area.

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	
Improved biomass stove - The combustion chamber is well insulated - Fuel rests on a shelf	
Clean fuel stove - Liquefied petroleum gas (LPG) stoves	

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