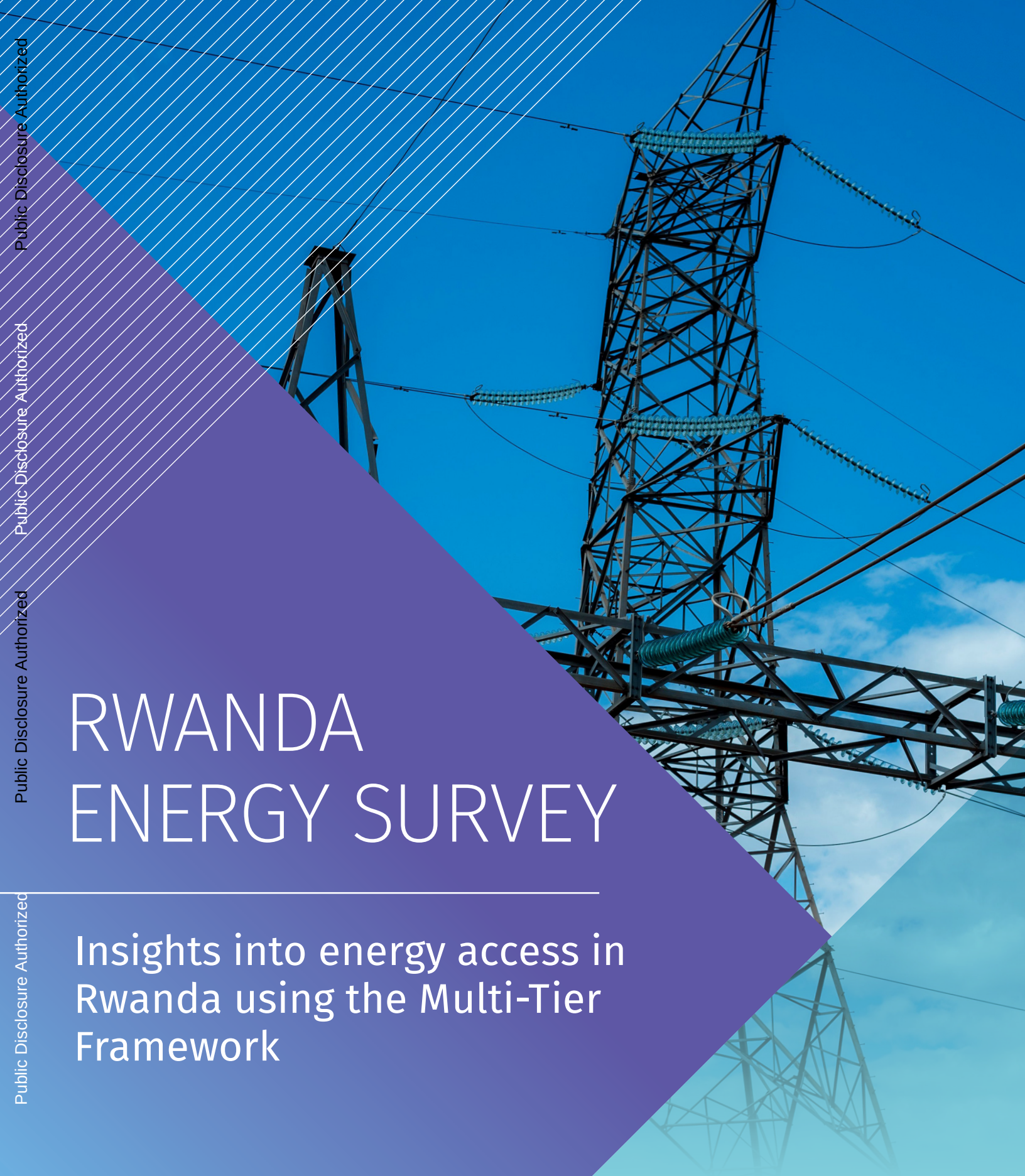

RWANDA ENERGY SURVEY

Insights into energy access in Rwanda using the Multi-Tier Framework

ESMAP
Energy Sector Management Assistance Program

THE WORLD BANK
IBRD • IDA

MINISTERO DELL'AMBIENTE E DELLA SICUREZZA ENERGETICA

MTF Multi-Tier FRAMEWORK

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Hyun Jin Choi, Bryan Bonsuk Koo

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MTF Multi-Tier FRAMEWORK

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This report delivers findings from a comprehensive energy survey carried out in Rwanda in mid-2022 by the Centre for Economic and Social Studies Ltd (CESS Ltd), under contract to the World Bank. The energy survey was based on the methodology developed under the Multi-Tier Framework (MTF) for Energy Access, a global initiative technically and financially supported by the Energy Sector Management Assistance Program (ESMAP) and administered by the World Bank. The survey findings have been analyzed and presented in this report by World Bank staff from ESMAP and the Rwanda energy team.

The authors for this report were Hyun Jin Choi (Data Analyst Consultant) and Bryan Bonsuk Koo (Energy Specialist). The field coordinator for the energy survey was Marina Brutinel (Energy Consultant), and the report was peer reviewed by Juan Carlos Parra Osorio (Senior Economist), Rutu Dave (Senior Energy Specialist), and Clementine Umugwaneza (Energy Specialist). Review, feedback, and editing were also provided by Norah Kipwola (Senior Energy Specialist), Yabei Zhang (Senior Energy Specialist), Arun Singh (Energy Specialist), Unurtsetseg Ulaankhuu (Energy Specialist Consultant), Meskerem Mulatu Legesse (Gender Specialist Consultant), Clara Galeazzi (Consultant), and Crispin Pemberton-Pigott (Senior Technical Consultant). Copyediting services were provided by Steven Kennedy, and design services were provided by Lauren Kaley Johnson and Duina Reyes.

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ABBREVIATIONS

EA	enumeration area
ESMAP	Energy Sector Management Assistance Program
GDP	gross domestic product
GoR	Government of Rwanda
kW	kilowatt
kWh	kilowatt-hour
LED	light-emitting diode
LPG	liquefied petroleum gas
MECS	modern energy cooking services
MINEMA	Ministry in charge of Emergency Management
MTF	Multi-Tier Framework
NISR	National Institute of Statistics of Rwanda
RE4R	Renewable Energy for Refugees
RWF	Rwandan franc
SHS	solar home system
SLS	solar lighting system
W	watt
WTP	willingness to pay
UNHCR	United Nations High Commissioner for Refugees
US$	United States dollar

CURRENCY EQUIVALENTS

(Exchange Rate Effective on June, 2022)

Currency Unit = Rwandan Franc (RWF)

US$ 1 = RWF 1,023

EXECUTIVE SUMMARY

This report presents the findings from a national energy survey conducted in Rwanda in June 2022, which followed up on an inaugural energy survey conducted in 2016. The survey captured the status of access to electricity and clean cooking among Rwandan households, including those of refugees, and also among public institutions. Survey results were analyzed using the Multi-Tier Framework (MTF) for Energy Access, which measures energy access across six levels (Tier 0 to Tier 5) instead of evaluating it based on a binary definition, having access or not, and explores the multi-dimensional nature of energy access and the diverse technologies and sources that can provide it. Findings from this analysis based on full-spectrum data can inform energy policy designs in Rwanda, empower data-driven policy making, and aid in advancing toward Goal 7 of the 17 Sustainable Development Goals of the United Nations: to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030.

The MTF measures electricity access in Rwanda using six attributes: electricity capacity, number of hours during which electricity is available across an entire day and specifically in the evening, reliability of connection, voltage quality, formality of connection, and safety. For each attribute, households are placed in a tier depending on the level of service. The lowest tier score achieved across the six attributes is a household's final tier classification, or the aggregate Electricity Tier. Households are classified from Tier 0 (no access) to Tier 5 (full service). Households classified as Tier 1 or above for their aggregate Electricity Tier have electricity access but at a level and quality that might need improvement. Tier 0 households do not have any access to electricity or have electricity whose capacity or availability is too low to be considered.

Using a similar approach, access to clean cooking is evaluated based on four attributes: exposure to pollutants from emissions during cooking activities, cooking convenience, stove safety, and fuel availability. The lowest tier score achieved by a household among the four attributes becomes its final tier classification, or the aggregate Cooking Tier. Households are classified from Tier 0 to Tier 5. Households in aggregate Tier 2 or above have access to clean cooking services (aggregate Tiers 4 and 5) or at least have improved cooking services in the transition to clean cooking (aggregate Tiers 2 and 3).[1] Households at Tiers 0 and 1 are not considered as having access to clean cooking services since their health and safety are critically threatened by their cooking activities.

[1] Tier 2 is no longer promoted through the World Bank programs starting from 2024.

ACCESS TO ELECTRICITY

The second national energy survey in Rwanda shows that electricity access improved significantly; the percentage of Rwandan households with access to at least one source of electricity nationwide increased from 28.6 percent in late 2016 to 63.9 percent in mid-2022.[2]

While major progress was made in rural electrification, rural-urban disparity in electricity access remained large in 2022. Marked growth in rural electricity access, from 17.5 percent to 57.9 percent, was registered over 2016–22, but by 2022 the rural access rate remained 33.7 percentage points lower than the urban access rate of 91.6 percent. **Lack of electricity access remains a challenge for rural areas.**

The national grid is the most prevalent electricity source, especially in urban Rwanda, including the City of Kigali. Nationwide, 50.7 percent of households relied on the national grid as their primary electricity source in 2022, more than double the share in 2016. In rural areas, 42.2 percent of households relied on the grid as their primary electricity source in 2022, versus 89.3 percent of urban households. Across regions, 93.8 percent and 54 percent of households in the City of Kigali and Eastern Province, respectively, were connected to the grid. In all other provinces, less than half of the population was grid-connected.

Off-grid technologies, especially solar solutions, serve as effective electricity sources for Rwanda's rural households, of which 15.7 percent rely on them as their primary electricity source. A much smaller proportion of urban households, 2.4 percent, choose these solutions. Solar lighting systems (SLSs) are the most popular off-grid technology in Rwanda, besides solar lanterns. In most provinces, at least 1 household in 10 uses off-grid technologies, whereas the proportion is negligible in the City of Kigali.

Electricity access is low among households that are socioeconomically more vulnerable. Ubudehe Category 1[3] shows the highest share of households without electricity access and the lowest proportion of households with grid access. The share of national grid-connected households grows as the Ubudehe category increases, but the share of households without any electricity source falls.

Nationwide, 58.9 percent of households have electricity access at the level of Tier 1 or higher based on the MTF analysis. The remaining households either do not have access to any electricity sources, or the capacity and/or availability of the electricity they receive are/is too low to be considered as having access. About half of rural households have Tier 1 or higher electricity access, while the share is much larger, 90.9 percent, among urban households. Analysis of individual electricity attributes shows **a need to improve the overall quality of electricity, including its availability, reliability, and voltage quality**.

Although access to the national grid grew substantially between 2016 and 2022, the consumption of grid electricity remained low. The monthly average grid consumption of Rwandan households was 16.8 kilowatt-hours (kWh), lower than the average consumption in nearby East African countries like Kenya (48.6 kWh) and Uganda (42 kWh). By locality, urban households consumed 28.6 kWh of electricity on average per month, while rural households consumed 11.3 kWh. Despite being connected to the national grid, households often do not leverage the capacity available to them from the grid and use mostly low-load devices.

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[2] The 5th Rwanda Population and Housing Census in 2022 showed that 61% of Rwandan households nationwide have electricity access (NISR 2023).

[3] The Ubudehe system of categorization was used by the Government of Rwanda to determine Rwandan households' eligibility for social protection interventions, including public works, direct support, community-based health insurance, and education grants. Category 1 indicates the highest degree of socioeconomic vulnerability, which decreases up through Category 4. As of 2024, the Government of Rwanda was transitioning away from the Ubudehe classification and adopting a new system to identify beneficiaries of social protection programs (Nkurunziza 2023). When the energy survey was implemented in mid-2022, the Ubudehe categories of households were available to be analyzed.

For unelectrified households in villages where access to the national grid is available, the cost burden of an initial connection is the major barrier to grid connection. Despite a 2017 policy allowing households to apply for a grid connection at no initial cost and repay the fee over time from power purchases (Rwanda Energy Group 2017), almost half of unelectrified households with grid access find initial connection costs expensive.

Interrupted service is a common issue faced by the majority of Rwandan households connected to the national grid. Of households with grid connections, 57 percent experience either 4–14 outages per week, or fewer than 4 interruptions, however, lasting longer than 2 hours in total in a typical week.

Households using an off-grid solar solution as their primary electricity source report limited electricity availability, low capacity, and poor light quality as common challenges. **Among households using solar home systems, 16.7 percent report the burden of recurrent device-related costs as a challenge.**

Among Rwanda's public institutions, the rate of electricity access is high; they predominantly use the grid as their main electricity source. All Rwandan health facilities have electricity access, and 98.5 percent use grid electricity. Electricity access in education facilities is relatively lower, at 86.3 percent. Among schools with access to electricity, 85.6 percent rely on the national grid, while the rest use off-grid solar technologies.

ACCESS TO MODERN ENERGY COOKING SERVICES

Clean cooking practices were rare in Rwanda as of 2022. Only about 4 percent of households cooked with clean stoves like liquefied petroleum gas (LPG) stoves or electric stoves; 67.2 percent were still using three-stone/open-fire stoves or traditional/locally built stoves that mostly burn firewood.

Clean stoves are used mostly in urban areas; their rate of use is highest in the City of Kigali. In 2022, 19 percent of urban households used LPG stoves for cooking—a sharp increase from 1.7 percent in 2016. However, only 0.6 percent of rural households had adopted LPG stoves. More than one-fifth of households in the City of Kigali cooked with LPG stoves, whose use outside the capital was negligible.

Households in higher Ubudehe categories tend to use cleaner stoves. The use of LPG stoves and manufactured biomass stoves is highest among Category 3 households, with the share declining among households in lower categories.

Wood is the predominant cooking fuel, especially in rural areas, where it is used for cookstoves by almost 90 percent of households, compared with an urban share of about 20 percent. In urban areas, charcoal is the most prevalent fuel, used by 73.5 percent of households.

Most households are exposed to threats from unhealthy cooking practices. The analysis using the MTF shows that in 2022, only about 4 percent of households nationwide had access to clean cooking. On overwhelming majority, 92 percent, of households were classified at Tiers 0 and 1 for cooking; this suggests that most Rwandan households continue to be exposed to threats from unhealthy cooking practices. Among rural households, 97 percent lie between Tiers 0 and 1, whereas the share is 69 percent in urban areas. Although urban areas have better access to clean cooking, with a higher proportion of Tier 5 households (19 percent) than in rural areas (0.6 percent), clean cooking access remains low overall.

Improved firewood cookstoves and LPG stoves could be options to expand clean cooking practices; however, their low affordability could hamper the transition. Most households using either three-stone/open-fire stoves or traditional biomass are willing to pay for an improved firewood cookstove either in a lump sum or in installments, especially when the stoves are cheaper. However, households not willing to pay for improved stoves report affordability as a barrier. LPG stoves can be suggested as clean cooking options to households in urban areas, where they are commonly available, but the high fuel cost would pose a barrier.

GENDER ANALYSIS

Male-headed households are predominant at 75.4 percent nationwide. The gender ratio is similar across rural and urban areas. Ubudehe Category 1 shows a higher share of female-headed households than male-headed households, indicating that female-headed households are poorer. Male household heads are more likely to be educated and employed than their female counterparts.

A gender gap exists in access to electricity and modern energy cooking solutions. **Electricity access is lower among female-headed households than male-headed households by about 10 percentage points.** Grid adoption is higher among male-headed households also by about 10 percentage points. Off-grid technology use is similar across the sexes.

The status of clean cooking access does not differ significantly by the sex of the household head. Male heads are slightly more likely to adopt LPG stoves than their female counterparts if the stoves are available (with a difference of 9.4 percentage points).

Female household members are more involved in cooking activities in Rwanda. While 75.2 percent of female household heads are cooking for their family every day, the rate is only 6.6 percent for male heads; 70.7 percent of male heads do not cook for their families. Also, female household members spend on average 86 minutes cooking every day, whereas male members spend only 17 minutes; this indicates that female household members would benefit the most from improved cooking practices.

REFUGEE HOUSEHOLD ANALYSIS

Refugees in Rwanda are accommodated in five settlements under the management of the Rwanda Ministry in charge of Emergency Management (MINEMA) in collaboration with the United Nations High Commissioner for Refugees (UNHCR): the Mahama and Nyabiheke camps in the Eastern Province, the Kiziba camp in the Western Province, and the Kigeme and Mugombwa camps in the Southern Province.

ACCESS TO ELECTRICITY

Across the five refugee settlements, 38.3 percent of households have access to at least one electricity source—a share lower than the 57.4 percent seen in the host communities surrounding the refugee camps. **While the host communities and refugee settlements are adjacent, access to the national grid is available only to host communities, whereas the refugee households mainly rely on off-grid solutions (37.9 percent) for electricity, especially on solar lanterns (17.6 percent) and other SLSs (13.1 percent).**

Mugombwa and Kigeme camps have relatively low electricity access. All camps, except Kiziba and Nyabiheke, show a major access disparity with their host communities. The use of SLSs is the highest in Nyabiheke, while the use of solar lanterns is the highest in Mahama.

Only about 15 percent of refugee households have Tier 1 or higher electricity access based on the analysis using the MTF although 38.3 percent of refugee households have access to at least one electricity source. In contrast, 49 percent of households in host communities have Tier 1 or higher electricity access. Almost 40 percent of host community households have Tier 3 to Tier 5 electricity access, due to their connections to the national grid, whereas almost no households in refugee settlements are in that tier range. **The analysis using the MTF confirms, again, the clear disparity in electricity access between refugee settlements and host communities despite their close proximity.**

While 34.7 percent of refugee households with electricity sources receive 4-8 hours of electricity in an entire day, 19.9 percent receive fewer than 4 hours. Refugee households use primarily low-load electrical appliances, and phone chargers are the most common appliances.

Most refugee households paid for their main solar devices rather than obtaining them for free. Households using solar lanterns most commonly made a lump sum payment for the solar devices, whereas households using SLSs often paid in installments.

Short duration of service and the inability to power large appliances were reported as the most serious challenges by refugee households using solar lanterns or SLSs. Almost 20 percent of households using solar lanterns reported that their devices malfunctioned too often, while almost 10 percent of households using SLSs reported the same issue.

ACCESS TO CLEAN COOKING

Of households in the refugee camps, 62.1 percent have access to clean stoves, more specifically, LPG stoves. The rate is significantly higher than among non-refugee households; only 4 percent of Rwandan households and 0.3 percent of host community households use LPG stoves. LPG stoves' adoption in refugee camps is explained by the intervention of the UNHCR. The use of LPG stoves is observed only in Mahama and Mugombwa, where the UNHCR distributed LPG cookers and fuel to replace the use of firewood. In other camps, households predominantly use biomass stoves for cooking.

In line with the high rate of LPG stove adoption, **LPG is the most used fuel; 63.7 percent of households in refugee camps use it.** Wood is also commonly used for cooking; 22.8 percent of refugee households use firewood, either purchased or collected. Charcoal use is comparatively low; 13.5 percent of refugee households use charcoal for their traditional/locally built stoves and manufactured biomass stoves.

1. INTRODUCTION

1.1 COUNTRY CONTEXT

Without energy, it is challenging, if not impossible, to promote economic growth, overcome poverty, and support human development. Energy access is thus a precondition to many development goals. Indeed, sustainable energy is the focus of Goal 7 of the 17 UN Sustainable Development Goals: to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030. The Government of Rwanda, steadfastly committed to maximizing energy access benefits for its people, has therefore collaborated with the World Bank to put findings from the Multi-Tier Framework (MTF) survey into practice and obtain guidance on setting access targets, policies, and investment strategies for energy access.

Rwanda is one of the rapidly growing low-income countries in Sub-Saharan Africa. Its gross domestic product (GDP) increased steadily from the early 2000s, reaching 13.3 billion current US dollars in 2022 (World Bank, n.d.b). Rwanda's annual GDP growth in 2021/22 was 8.2 percent (World Bank, n.d.c). Electricity access in Rwanda improved rapidly entering the 2010s. In 2014, 19.8 percent of its population had electricity access (World Bank, n.d.a), and the rate increased to 28.6 percent in 2016, according to the energy survey from 2016 (Koo et al. 2018). In 2022, the second MTF energy access survey conducted in Rwanda indicated that 63.9 percent of households had access to at least one source of electricity—a substantial rise from 2016.

1.2 METHODOLOGY: THE MULTI-TIER FRAMEWORK

The Energy Sector Management Assistance Program (ESMAP), a global knowledge and technical assistance program of the World Bank, in consultation with multiple development partners,[4] has developed the MTF to measure energy access in a detailed manner. Unlike the traditional binary measurement of energy access—revealing, for example, either electricity access or the lack of it, and the use or not of clean fuels when cooking—the MTF approach involves a multi-level measure of energy access provided by any technology or fuel, based on a set of attributes that capture key characteristics of energy supply affecting the user experience. Each attribute is assessed separately in tiers, and the lowest applicable tier achieved among the attributes is a household's aggregate tier, ranging from Tier 0 (no access) to Tier 5 (full service) (Bhatia and Angelou 2015).

Grounded in the MTF, the global energy survey was developed to capture countries' energy access situations. The energy survey collects data on access to electricity and modern energy cooking services (MECS), including households' primary energy sources; the challenges with these energy sources; energy-related spending; and people's willingness to pay for the national grid connection, off-grid energy service, and improved cooking solutions. The data collected are then analyzed using the MTF approach. A key issue that the survey explores is the nature of the

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

barriers that prevent a household from moving to a higher tier of access to electricity and clean cooking. By capturing full-spectrum data, the analysis empowers policy makers to pursue data-informed energy policies and to design interventions that remove barriers, so households can graduate to higher tiers.

ACCESS TO ELECTRICITY

Access to electricity is defined by analyzing the following seven electricity attributes based on responses to the energy survey:

- **Capacity.** The capacity of electricity supply (or peak capacity) is a system's ability 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. The capacity is estimated based on the supply source (for example, grid power is considered ≥2,000 W) and/or the appliances used by a household (table 1). Capacity is measured in watts for grids, mini-grids, and fossil-fuel-powered generators, and in watt-hours for rechargeable batteries and off-grid solar devices.
- **Availability.** Availability of supply refers to the amount of time during which electricity is available. It is measured via two separate indicators: hours per day (during each 24-hour period) and the number of hours per evening (defined as the 4 hours after sunset).
- **Reliability.** Reliability of supply is a combination of the frequency and duration of unexpected disruptions.
- **Quality.** Quality refers to the absence of severe voltage fluctuations that can damage a household's appliances. Electrical appliances generally require a specific voltage to operate properly. Low or fluctuating voltages can damage appliances and even result in electrical fire. Low voltage supply or voltage fluctuations tend to result from an overloaded distribution system or from long-distance, low-tension cables connecting spread-out households to the grid. The survey does not measure voltage fluctuation directly but uses incidents of appliance damage as a proxy.
- **Affordability.** Affordability of electricity services 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. An electricity service is considered unaffordable for any household that needs to devote more than 5 percent of its expenditure to it.
- **Formality.** A household's grid connection could be defined as informal if it uses electricity from the grid but does not pay anyone for it. The formality of the grid connection is important since it ensures that the electricity authority is paid for the services provided, besides providing for the safety of electrical lines. Households may well be reluctant to disclose such information in a survey. The survey therefore infers information on formality from indirect questions that respondents may be more willing to answer, for example, what method a household uses to pay its electricity bills.
- **Health and Safety.** This attribute refers to injuries to household members from using electricity in the 12 months preceding the survey. An injury could mean a limb injury or even death due to a burn or electrocution. Such injuries can result not just from faulty internal wiring (an exposed bare wire, for example) but also due to improper use of electrical appliances or negligence. Electricity access is considered safe when users have not suffered any significant or lasting injury from their electricity supply.

For the analysis of the energy survey in Rwanda, electricity access was measured using six attributes instead of seven—Capacity, Availability, Reliability, Quality, Formality, and Safety; this is because the survey did not collect data to analyze the Affordability attribute. For each attribute, households are placed in a tier depending on the level of service as defined by the different thresholds (see figure 7 for the thresholds in the multi-tier matrix for measuring electricity access). The lowest tier value obtained by a household among the attributes becomes that household's aggregate Electricity Tier, reflecting its level of electricity access.

Households in Electricity Access Tier 0 receive electricity for fewer than 4 hours a day (or fewer than 1 hour per evening) or have a primary energy source with less than 3 W capacity (see box 2 for the minimum requirements, by Electricity Access Tier). Tier 1 refers to households that have limited access to small amounts of electricity supplied by any technology, even a small solar lighting system, for a few hours a day, enabling electric lighting and phone charging.

TABLE 1 • Appliances by load level and the associated Capacity Tiers

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

Source: Bhatia and Angelou 2015.

Note: W = watt.

BOX 1 • TYPOLOGY OF OFF-GRID SOLAR DEVICES AND TIER CALCULATION

In this report, solar devices are classified into three types based on the number of light bulbs and the type of appliance or electricity service used by a household: solar lanterns, other solar lighting systems (SLSs), and solar home systems (SHSs).[a] This typology is also used to measure electricity access under the Multi-Tier Framework (MTF) approach, especially the Capacity attribute.

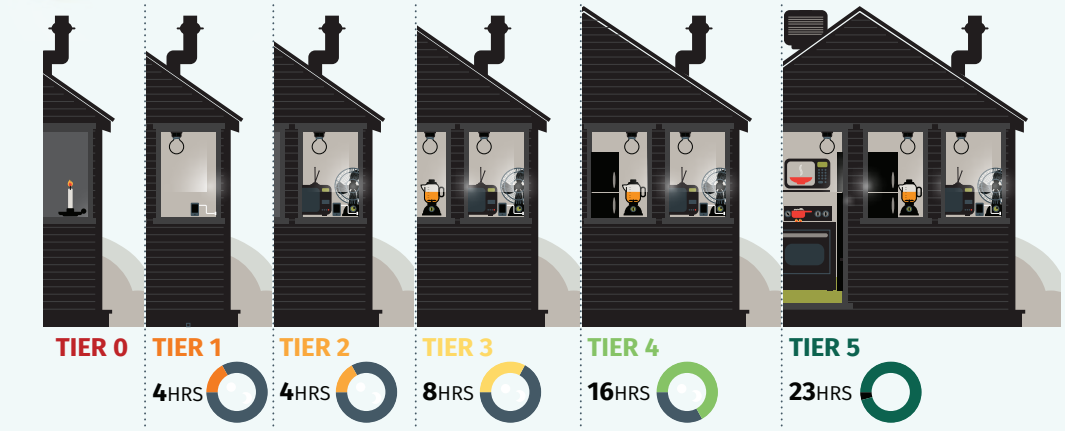
- **Solar lanterns** power a single light bulb and could possibly power a radio and/or enable phone charging. Under the MTF methodology, the Capacity Tier for a solar lantern is computed based on the household size, so as to capture the number of household members relying on the service and the ability to power a radio and/or enable phone charging.
- **SLSs** power two or more light bulbs and could possibly power a radio and/or enable phone charging. However, SLSs cannot power any other appliances. The Capacity Tier for an SLS is computed based on the household size and the ability to power a radio and/or enable phone charging.
- **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).

[a] Note that the definition of SHSs in the analysis in this report is different from how Rwanda's Ministry of Infrastructure defines it. The ministry defines SHSs to be off-grid solar photovoltaic systems that include multiple, two or more, light points (Rwanda Ministry of Infrastructure 2022). However, based on the definition in this report, solar devices that could power two or more light bulbs could be SLSs or SHSs depending on the ability to power electrical appliances other than a radio and/or enable phone charging as described in box 1.

BOX 2 • MINIMUM ELECTRICITY REQUIREMENTS, BY ELECTRICITY ACCESS TIER

MEASURING ENERGY ACCESS: THE TIERS

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



Tier 0	Tier 1	Tier 2
Electricity is not available or is available for less than four hours a day (or less than one hour per evening). Households cope by using candles, kerosene lamps, or battery-powered devices, such as flashlights and radios.	Electricity is available for at least four hours a day, including at least one hour per evening, and the capacity is sufficient to power task lighting and phone charging or a radio. Sources that can be used to meet these requirements include an SLS, a solar home system (SHS), a mini-grid (a small-scale, isolated distribution network that provides electricity to local communities or a group of households), and the national grid	Electricity is available for at least four hours a day, including at least two hours per evening, and capacity is sufficient to power low-load appliances as needed during that time, such as multiple lights, a television, or a fan (see Table 1). Sources that can be used to meet these requirements include rechargeable batteries, an SHS, a mini-grid, and the national grid.
Tier 3	**Tier 4**	**Tier 5**
Electricity is available for at least eight hours a day, including at least three hours per evening, and capacity is sufficient to power medium-load appliances as needed during that time, such as a refrigerator, freezer, food processor, water pump, rice cooker, or air cooler (see Table 1). In addition, the household can afford a basic consumption package of 365 kilowatt-hours per year. Sources that can be used to meet these requirements include an SHS, a generator, a mini-grid, and the national grid.	Electricity is available for at least 16 hours a day, including at least four hours per evening, and capacity is sufficient to power high-load appliances as needed during that time, such as a washing machine, iron, hairdryer, toaster, and microwave. There are no long or frequent unscheduled interruptions, and the supply is safe. The grid connection is legal, and there are no voltage issues. Sources that can be used to meet these requirements include diesel-based mini-grids and the national grid.	Electricity is available for at least 23 hours a day, including 4 hours per evening, and capacity is sufficient to power very high load appliances as needed during that time, such as air conditioners, space heaters, vacuum cleaners, and electric stoves. The most likely source for meeting these requirements is the national grid, though a generator or mini-grid might suffice as well.

Source: Bhatia and Angelou 2015.

Note: HR = hour.

ACCESS TO MODERN ENERGY COOKING SERVICES

Besides stoves and fuel technologies, different contextual factors contribute to the household cooking experience. These factors include human behavior (for example, who cooks, and what is cooked and how, for how long, and how often), housing conditions (for example, kitchen location, arrangement and size of rooms, construction materials, and quality of ventilation), and other types of energy demands that may equally contribute to household air pollution (for example, lighting, space heating, and water heating). Other dimensions of household choice, adoption, and adherence—including economic conditions (for example, income/affordability and proximity to fuel markets)—should also be captured.

MECS integrate technical and contextual attributes that consider users' cooking experience, environment, and the market and energy ecosystems in which they live. MECS define access to modern cooking energy based on six attributes: (i) Exposure, (ii) Efficiency, (iii) Convenience, (iv) Safety, (v) Affordability, and (vi) Fuel Availability (ESMAP 2020):

- **Exposure.** This attribute is used to assess personal exposure to pollutants from cooking activities, which depends on both stove emissions and ventilation in the cooking area. Higher tiers indicate lower exposure.
- **Efficiency.** The combination of combustion and heat transfer efficiency determines a cookstove's efficiency.
- **Convenience.** This attribute is measured by the time spent by a household collecting or purchasing fuel and preparing the fuel and stove for cooking.
- **Safety.** Safety is measured by the severity of the injuries caused by a stove over the past year.
- **Affordability.** This attribute is used to measure the share of the household budget for cooking fuel. Cooking fuel is considered affordable if a household spends less than 5 percent of its total expenditure on it. Higher tiers indicate proportionally lower spending.
- **Availability.** This attribute is used to assess the availability of households' primary fuel when needed for cooking purposes.

The Rwanda energy survey did not collect data that make it possible to analyze efficiency and affordability. Thus, access to clean cooking was measured based on just four attributes: Exposure, Convenience, Availability, and Safety. Each attribute is scored across six tiers (Tiers 0–5), and these tiers are measured using one or more indicators, each spanning a lower and upper threshold (see figure 54 for detailed metrics).

BOX 3 • HOLISTIC CRITERIA TO MEASURE ACCESS TO MODERN ENERGY COOKING SERVICES

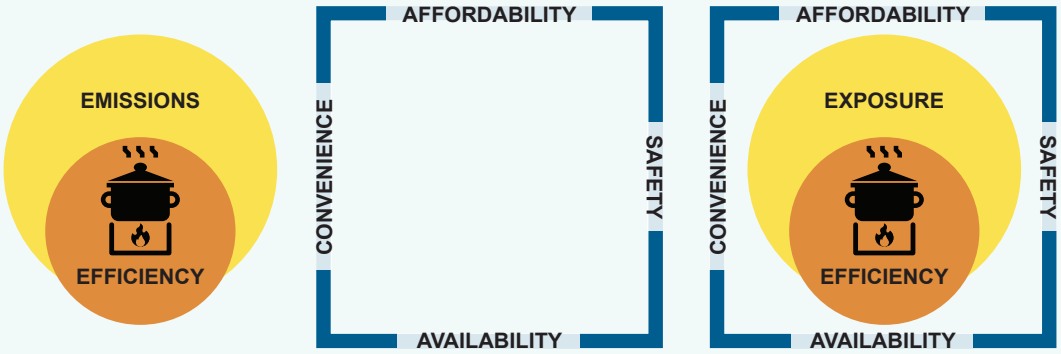
Performance-based, technical attributes that shape most definitions of "clean" cooking solutions

+

Attributes critical to understanding the household user's cooking context

=

Assessment of MECS access across the six attributes



Source: ESMAP 2020.

Note: "Exposure" considers the contextual factors of ventilation and contact time, in addition to the technical attribute of "emissions." MECS = modern energy cooking services.

BOX 4 • COOKSTOVE TYPOLOGY FOR RWANDA

Cookstoves in Rwanda are classified as follows (annex 7):

Three-stone/open-fire stoves balance a pot on three stones. The pot sits on the flames, with the fuel placed on the ground. In general, these stoves use firewood and have a low combustion temperature. The fire of these stoves is exposed, causing heat to be lost to the ambient air.

Traditional stoves (biomass, artisan, or self-built stoves) typically use conventional material to insulate the fire, and the pot rests above the flames. These stoves are also made locally using available, low-cost materials and fuels, reflecting cultural practices.

Improved cookstoves (biomass manufactured stoves) The conventional improved cookstove is a wood, charcoal, or pellet stove with an insulated combustion chamber. The pot sits above the fuel.

Kerosene cookstoves use kerosene or a liquid as fuel.

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

1.3 SURVEY IMPLEMENTATION IN RWANDA

The Rwanda energy survey conducted in June 2022 included field surveys whereby households and public institutions were interviewed on electricity access and clean cooking along with information on respondents' socioeconomic backgrounds.

SURVEY SAMPLING

Household Survey

The MTF household survey included two types of household samples from two sampling frames: nationally representative household samples and refugee household samples.

Nationally Representative Sample

To draw a nationally representative sample, a complete list of Rwandan households from the Rwanda Population and Housing Census Report 2012 (RPHC 2012), provided by the National Institute of Statistics of Rwanda, was used as the sampling frame. Enumeration areas (EAs) from the sampling frame were stratified into host communities of refugee camps, which referred to EAs within 5 km of refugee settlements, and non-host communities.

EAs in non-host communities were stratified by urban and rural areas in each province, and the number of EAs were allocated proportional to the estimated population size (table 2). In total, 223 villages were selected in the first-stage sampling. In the second stage of sample selection, based on households' electrification status from the listing, households in the EAs were stratified as electrified and non-electrified. A predetermined number of households, 18, were selected randomly in each EA. Of these, 50 percent were expected to be grid-electrified households and 50 percent non-grid-electrified households. In this report, responses from 4,000 non-host community households have been analyzed.

To sample host communities, a total of 56 EAs were randomly selected from among the communities within 5 km of each camp. Then in each village, 18 households were selected randomly (table 3). Responses from 1,006 households in host communities have been analyzed.

TABLE 2 • Distribution of sample households by province and locality

Province	Allocation of sample villages			Household allocation		
	Rural	Urban	Total	Rural	Urban	Total
City of Kigali	39	10	49	702	180	882
Southern Province	18	27	45	324	486	810
Eastern Province	21	24	45	378	432	810
Northern Province	16	22	38	288	396	684
Western Province	18	28	46	324	504	828
Total	112	111	**223**	2,016	1,998	**4,014**

Source: CESS Ltd. 2022a.

Households in Refugee Camps

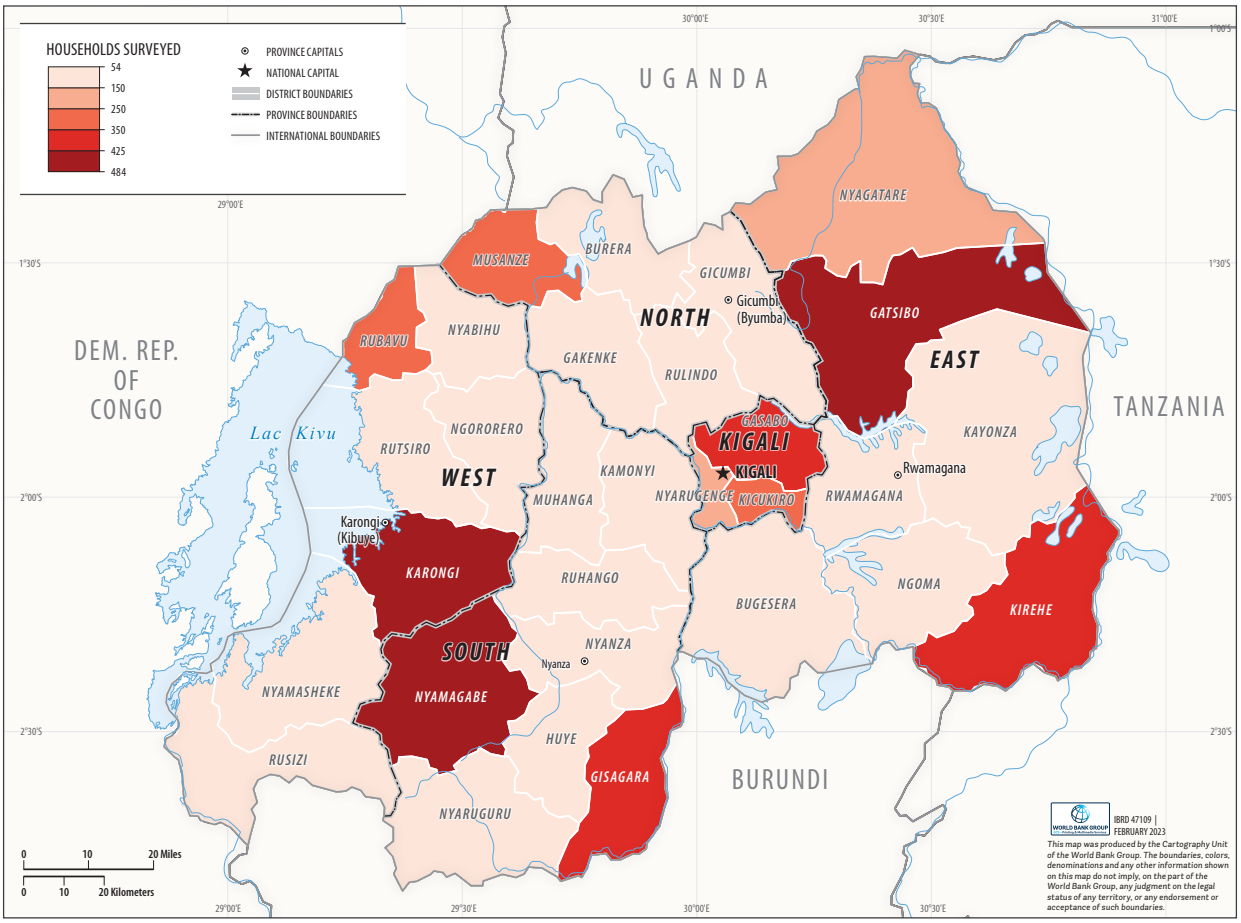
The refugee household survey was conducted in all five refugee camps in Rwanda: the Mahama and Nyabiheke camps in the Eastern Province, the Kiziba camp in the Western Province, and the Kigeme and Mugombwa camps in the Southern Province. The United Nations High Commissioner for Refugees Rwanda provided the list of segments in the refugee camps and the population size per segment. An exhaustive list of refugee households in the five camps was used for the sampling frame. To sample refugee households, first 39 segments of refugee camps were selected; in each segment, 18 refugee households were selected randomly (table 3). In the report, the responses of 700 refugee households have been analyzed.

TABLE 3 • Sample distribution for refugee camps and host communities

	Sample size of refugee camps		Sample size of host community households	
Refugee camps	**Segments**	**Households**	**EAs**	**Households**
Mahama	9	153	7	126
Kigeme	8	139	12	216
Kiziba	8	139	11	198
Nyabiheke	8	139	13	234
Mugombwa	7	130	13	234
Total	39	**700**	56	1**,008**

Map 1 shows the spatial distribution of household samples.

MAP 1 • Distribution of households sampled for the Rwanda energy survey



Source: World Bank 2023.

Public Institutions Survey

The public institutions survey targeted all health centers and education facilities in the selected villages from the first-stage stratification of the household survey. In total, interview responses from 196 education centers and 281 health facilities across Rwanda were analyzed.

2. ACCESS TO ELECTRICITY

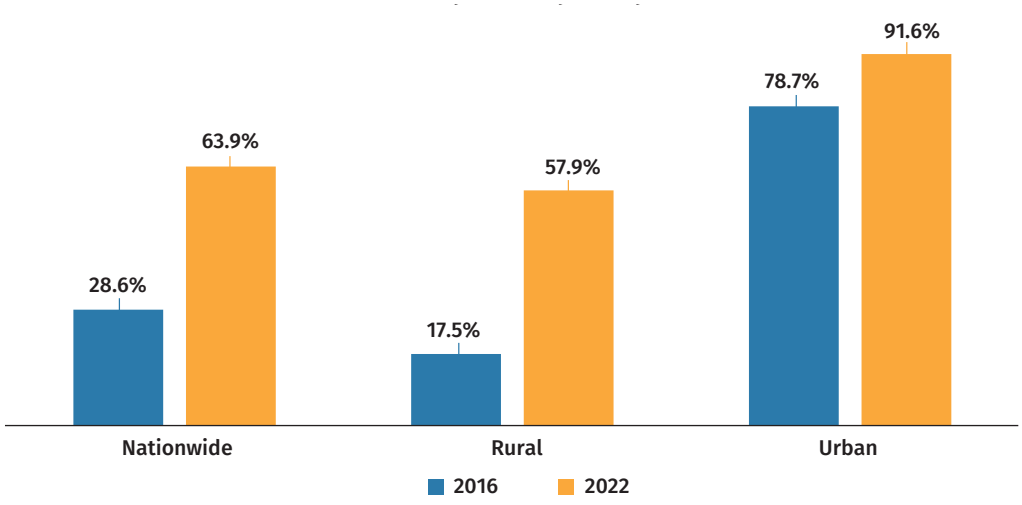
2.1 ASSESSING HOUSEHOLD ACCESS TO ELECTRICITY

ELECTRICITY ACCESS BY TECHNOLOGY

Nationwide

As of mid-2022, nationwide, 63.9 percent of Rwandan households had access to at least one source of electricity;[5] this was 35.3 percentage points higher than the access rate assessed from the 2016 energy survey (Koo et al. 2018) (figure 1). A large increase in electricity access was observed, especially in rural areas. In 2022, 57.9 percent of rural households had access to sources of electricity, a 40.4 percentage point improvement over the rate in 2016. Among urban households, 91.6 percent had access to at least one electricity source in 2022, whereas the rate was 78.7 percent in 2016. Although electricity access improved significantly in rural areas by 2022, there remains a substantial access gap of 33.7 percentage points between rural and urban areas, highlighting a need to focus on rural electrification.

FIGURE 1 • Electricity access in Rwanda, by locality (2016 vs 2022)



Sources: Koo et al. 2018; World Bank 2022.

Almost half of Rwandan households had access to the national grid as their primary electricity source in 2022. The share of households relying on the national grid as their primary electricity source more than doubled between 2016 and 2022 (figure 2). The use of the national grid increased significantly especially in rural areas. In 2022, 42.2 percent of rural households relied on the national grid, a 30.2 percentage point growth over 2016. Grid access grew 13.5 percentage

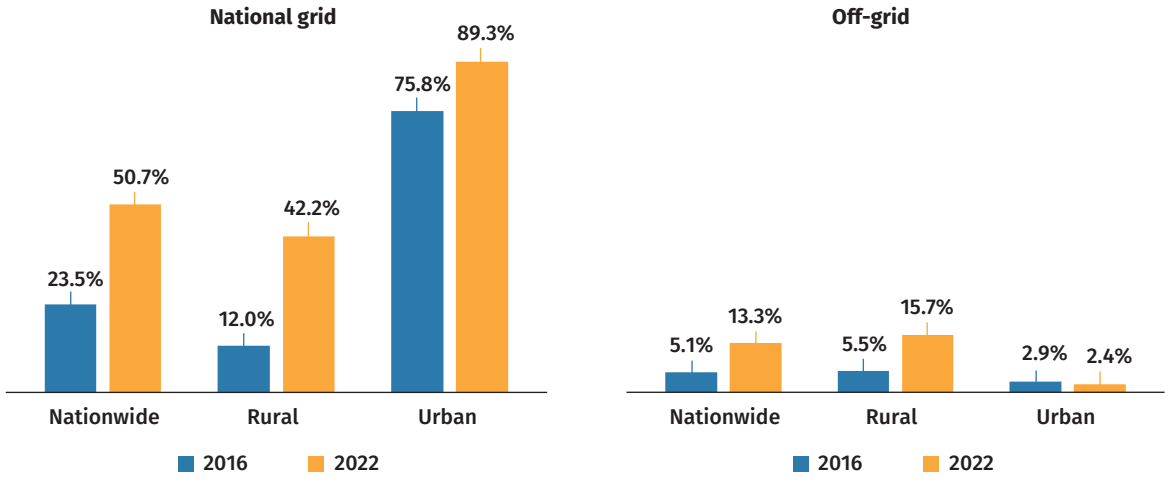
[5] This is based on households' primary electricity source. The options for primary electricity source in the survey were the national grid, off-grid technologies (mini-grids, generators, solar lanterns, other solar lighting systems [SLSs], solar home systems [SHSs], and rechargeable batteries), dry-cell batteries, or no electricity. Households that reported relying on dry-cell batteries as their primary electricity source were not considered to have electricity along with those who chose the "no electricity" option.

points among urban households, of which 89.3 percent relied on the grid in 2022. Although grid access improved significantly among rural households, their grid rate remains less than half of the rate among urban households.

Off-grid technologies serve as effective electricity sources for rural households, as made evident by the noticeable increase in their use.[6] In 2016, only 5.5 percent of rural households relied on off-grid solutions, whereas the share grew to 15.7 percent in 2022 (figure 2). The adoption of off-grid solutions was negligible in urban areas in 2022, as it had been in 2016.

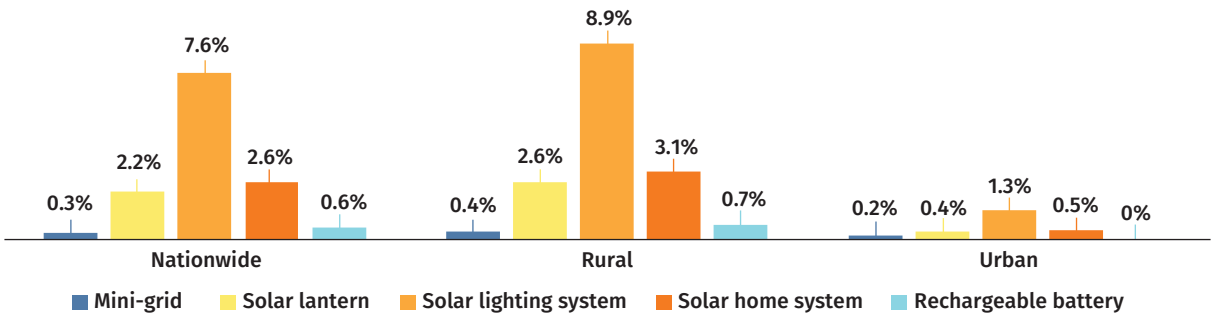
Among off-grid solutions, solar devices have been widely adopted. Households using solar lanterns, other solar lighting systems (SLSs), or solar home systems (SHSs) as their primary electricity sources represent a 12.4 percent share nationwide. SLSs are used the most by 7.6 percent of households (figure 3). Among rural households, 14.6 percent rely on solar solutions, 12.4 percentage points higher than the share in urban areas. Mini-grids and rechargeable batteries are rarely used.

FIGURE 2 • Electricity access, by technology (2016 vs 2022)



Sources: Koo et al. 2018; World Bank 2022.

FIGURE 3 • Distribution of off-grid technologies, by locality (2022)



Source: World Bank 2022.

[6] Off-grid technologies in the survey include mini-grids, generators, solar lanterns, other SLSs, SHSs, and rechargeable batteries. Note that no Rwandan household adopts generators as its primary electricity source, based on the survey's result.

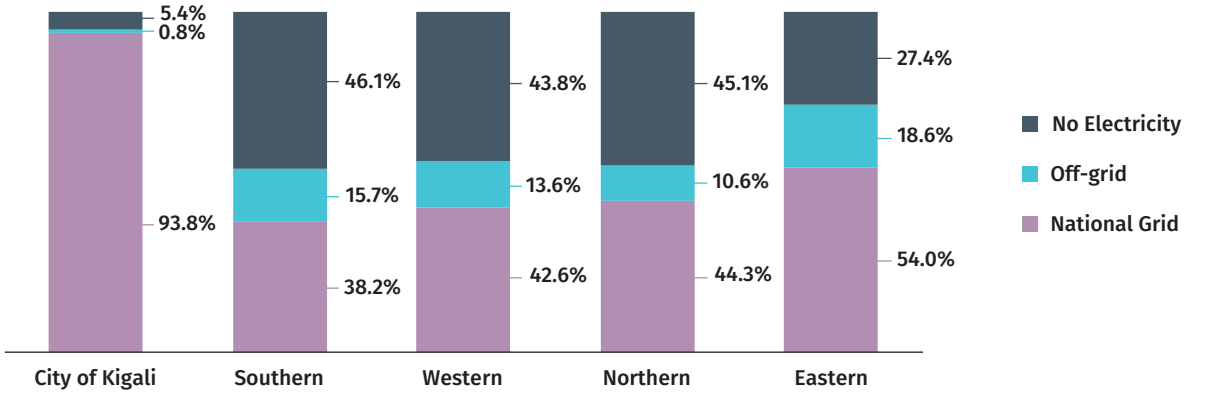
By Province

Across all provinces, the national grid is the most prevalent electricity source. Nevertheless, the City of Kigali, Rwanda's capital, has the highest number of households relying on the national grid as their primary electricity source; these households represent a 93.8 percent share, which is far larger than elsewhere (figure 4). In the Eastern Province, 54 percent of households rely on the national grid as their main source of electricity, whereas less than half of the population in the Southern, Western, and Northern provinces do so. This shows that future grid expansions should focus outside the City of Kigali.

Off-grid solutions are commonly used in most areas outside the City of Kigali (figure 4). The Eastern Province has the highest share of households relying on off-grid technologies, 18.6 percent. Across provinces, the most common off-grid technology is SLSs, besides solar lanterns, and their adoption does not differ substantially by region (figure 5). The use of SHSs is slightly more prevalent in the Eastern Province than in other provinces, but the solution is used by a small number of Rwandan households overall.

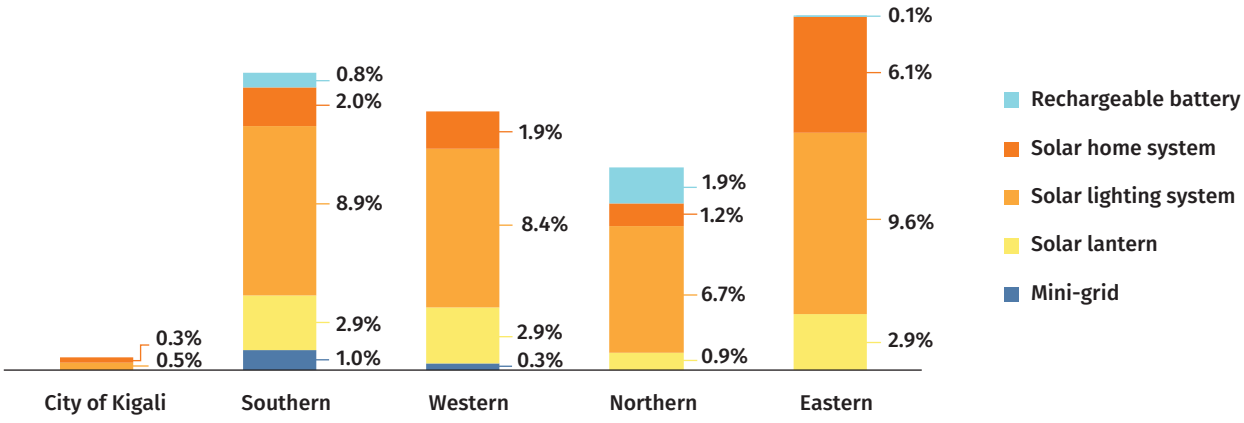
Access rates are particularly low in the Southern, Western, and Northern provinces. While 5.4 and 27.4 percent of households in the City of Kigali and the Eastern Province, respectively, are without electricity, the share is above 40 percent in the Southern, Western, and Northern provinces (figure 4). It is crucial to target the three lagging provinces to boost electricity access.

FIGURE 4 • Provincial electricity access, by technology



Source: World Bank 2022.

FIGURE 5 • Distribution of off-grid technologies, by province



Source: World Bank 2022.

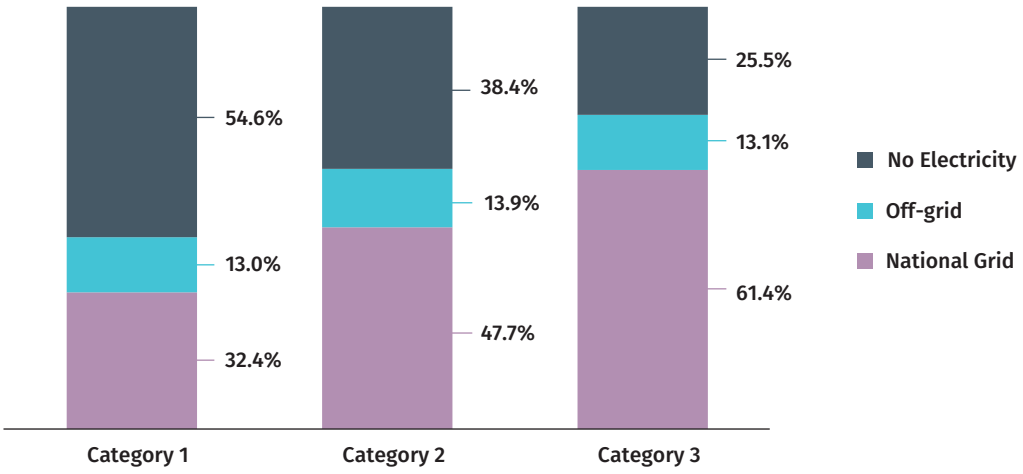
By Ubudehe Category

The Government of Rwanda has been using a socioeconomic categorization mechanism called Ubudehe to determine Rwandan households' eligibility for social protection interventions, including public works, direct support, community-based health insurance, and education grants (Rwanda Ministry of Local Government 2018).[7] Under the Ubudehe system, households were periodically categorized according to their poverty and vulnerability status as perceived by their communities (NISR 2015). The Ubudehe classification includes four categories, Category 1 to 4, in ascending order. Category 1 is the most socioeconomically vulnerable and Category 4 the least.

The energy survey collected the Ubudehe information of households and allowed data to be analyzed by category. The survey data allowed analysis of Category 1 to Category 3, while Category 4 households offered too few observations to allow analysis.

The analysis shows that the Ubudehe categorization was strongly correlated with electricity access and access to the grid. Not surprisingly, when the category increased, the percentage of households connected to the national grid increased, while the share of households without any electricity sources declined (figure 6).

FIGURE 6 • Access to electricity-providing technologies, by Ubudehe category (nationwide)



Source: World Bank 2022.

Note: Ubudehe Category 4 was not analyzed due to the low number of observations.

[7] As of 2024, the Government of Rwanda was transitioning away from the Ubudehe classification and adopting a new system to identify beneficiaries of social protection programs (Nkurunziza 2023). When the second energy survey was implemented in mid-2022, the Ubudehe categories of households were available to be analyzed.

EVALUATING ELECTRICITY ACCESS USING THE MULTI-TIER FRAMEWORK

Using the Multi-Tier Framework (MTF), households' level of electricity access is assessed based on six attributes, as shown in figure 7. The lowest tier score achieved by a household across the six attributes becomes that household's final tier classification, or the aggregate Electricity Tier. Households above Tier 0 in all attributes are classified above aggregate Electricity Tier 0. These households have electricity access, but its level and quality might need improvement. Households at aggregate Electricity Tier 0 barely have electricity access. They are at this tier because they either do not have access to any source of electricity at all, or are at Tier 0 for the Capacity and/or Availability attribute, meaning they receive electricity but its capacity and/or availability are/is too substandard to be considered as access (figure 7). In the following paragraphs, distributions of Rwandan households based on the aggregate tier will be presented first, and the tier distribution by each attribute will be discussed.

FIGURE 7 • MTF Electricity Tier matrix for the Rwanda survey analysis

ATTRIBUTE		TIER SCORE					
		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Capacity		<3 W	3–49 W	50–199 W	200–799 W	800–1,999 W	≥2 kW
Availability	Day	<4 hrs	-	4–8 hrs	8–16 hrs	16–22 hrs	≥23 hrs
	Evening	<1 hr	1–2 hrs	2–3 hrs	3–4 hrs	-	4 hrs
Reliability		-			Disruptions > 14	(4–14 disruptions) or (Disruptions ≤3 and Duration ≥2 hrs)	(Disruptions ≤3) and (Duration <2 hrs)
Quality		-			With voltage issues	-	No voltage issues
Formality		-			Informal	-	Formal
Safety		-			Had past accidents	-	Safe, no accidents

Source: Bhatia and Angelou 2015.

Note: Tier score range is different for each attribute. A gray cell or block refers to a tier or tiers that do not need to contribute to the relevant score range. For example, a binary/bipolar situation will require only two tiers, and hence, the apparently discontinuous or partial sequences of tiers illustrated. The Affordability attribute is excluded from the table since it was not included in the analysis of the survey in Rwanda. hr = hour; kW = kilowatt; W = watt

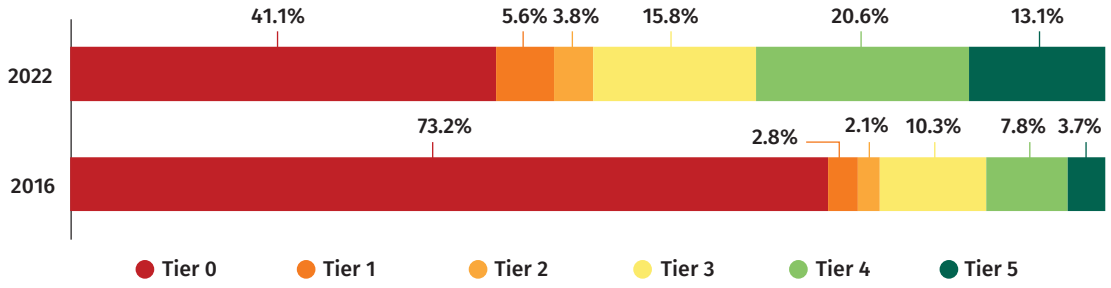
Aggregate Electricity Tier

The MTF analysis shows that as of 2022, nationwide, 58.9 percent of Rwandan households had electricity access at the level of Tier 1 or above (figure 8). Compared with 2016, the share of households in the same tier range grew 32.1 percentage points in 2022. Nationwide, 41.1 percent of Rwandan households remained at Tier 0 in 2022, with barely any electricity access.

Rwandan households in higher aggregate tiers predominantly rely on the national grid as their primary electricity source. Lower-tier households mainly use solar devices. As shown in figure 9, Tier 3 or higher households predominantly rely on the national grid. Despite a grid connection, some households are at Tier 2 to Tier 4, indicating that they face quality issues with their grid electricity.

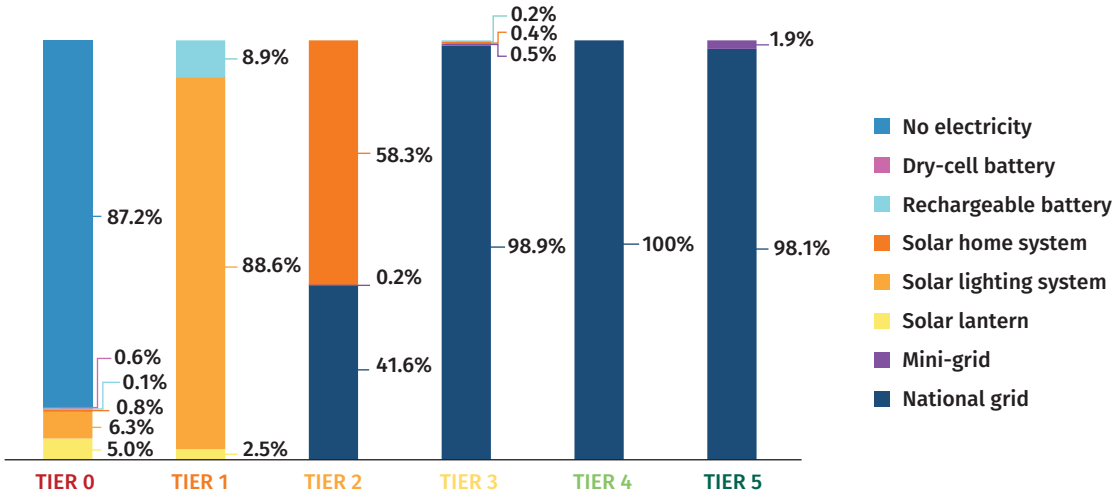
The use of solar technologies is common among Tier 1 and 2 households (figure 9). Among Tier 2 households, 58.3 percent use SHSs as their primary electricity source, and 88.6 percent of Tier 1 households adopt SLSs other than solar lanterns. Most Tier 0 households do not have any source of electricity, and about 12 percent use electricity from solar devices of limited capacity and/or availability.

FIGURE 8 • Nationwide household distribution of aggregate Electricity Tier



Sources: Koo et al. 2018; World Bank 2022.

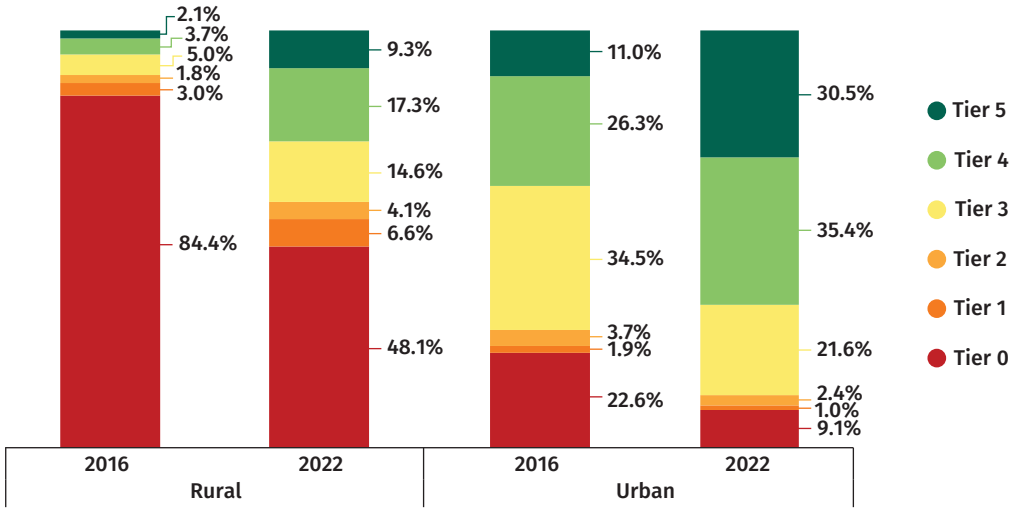
FIGURE 9 • Household distribution based on electricity-providing technology, by aggregate Electricity Tier (2022)



Source: World Bank 2022.

Tier distribution by locality shows that, while electricity access in rural areas improved markedly between 2016 and 2022, a large rural-urban disparity remained. In 2022, 51.9 percent of rural households had electricity access at Tier 1 or above, 36.3 percentage points more than in 2016 (figure 10). In urban areas, the growth was 13.5 percentage points. Although electricity access showed the largest improvements over time in rural areas, the share of rural households with electricity access remained 39 percentage points lower than in urban areas.

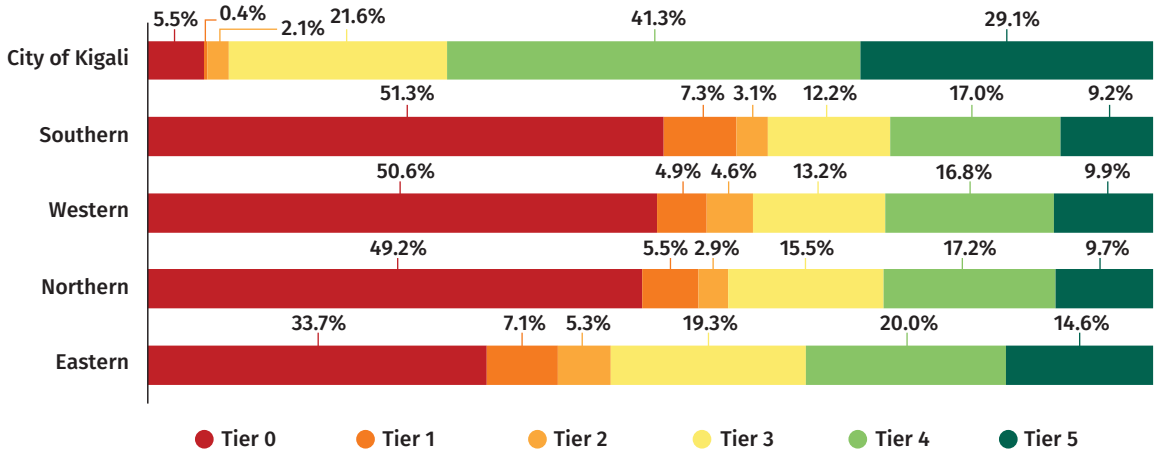
FIGURE 10 • Household distribution of aggregate Electricity Tier (rural/urban)



Sources: Koo et al. 2018; World Bank 2022.

The gap in the level of electricity access between the City of Kigali and the rest of the country is considerable. In the City of Kigali, 94.5 percent of households are classified above aggregate Tier 0, while in the Eastern Province, households with electricity access represent a much lower share, 66.3 percent, and the share is only about 50 percent in all other provinces (figure 11).

FIGURE 11 • Provincial household distribution of aggregate Electricity Tier



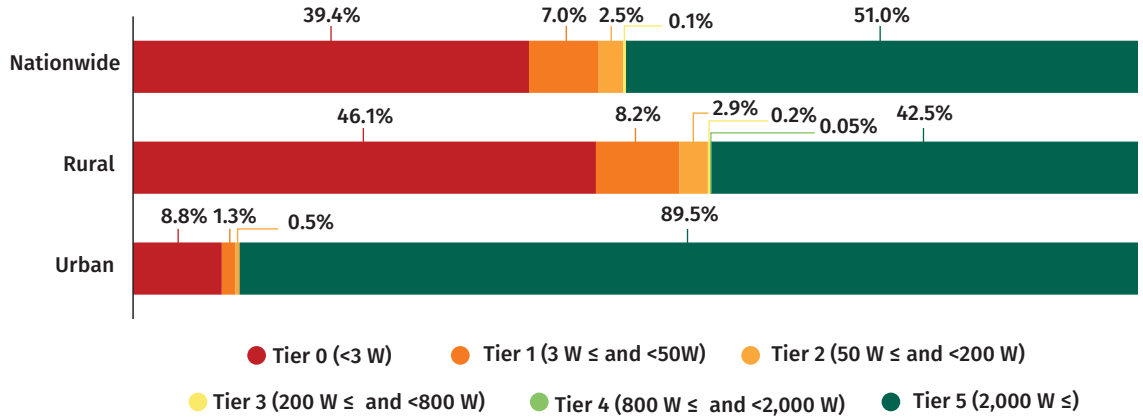
Source: World Bank 2022.

By Attribute

Capacity

The Capacity attribute represents the ability to provide electricity to power appliances. As of 2022, capacity was more of an issue in rural Rwanda. As shown in figure 12, while capacity is high for almost 90 percent of urban households, at 2,000 W or above, the share is only 42.5 percent in rural areas. The high share of rural households below Tier 3 for the Capacity attribute includes mostly those without any electricity sources and those using off-grid solar solutions with limited capacity (figure 13). Changes in tier distribution over time could not be captured due to a lack of data on the Capacity attribute from 2016.

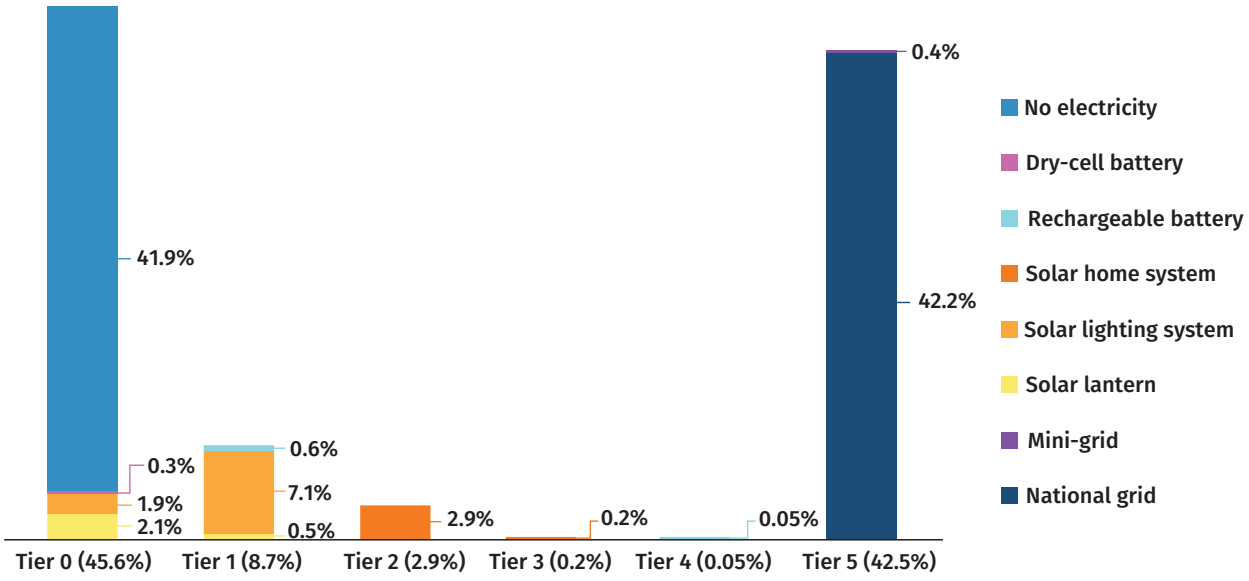
FIGURE 12 • Household distribution of Capacity Tier, by locality (2022)



Source: World Bank 2022.

Note: W = watt.

FIGURE 13 • Household distribution based on electricity-providing technologies in rural areas, by Capacity Tier



Source: World Bank 2022.

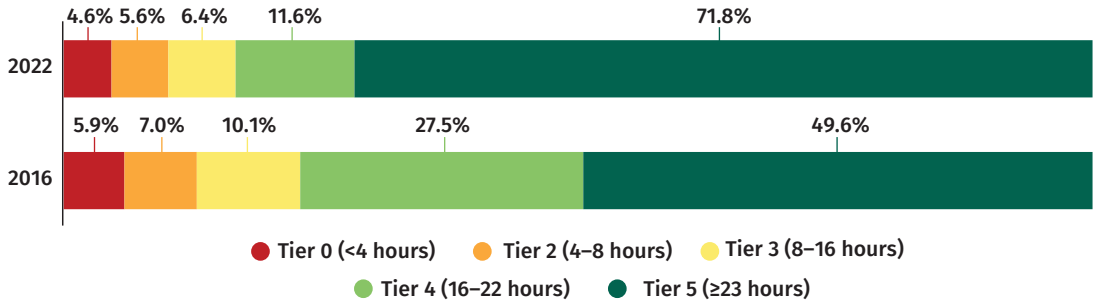
Availability

The Availability attribute considers households that have at least one source of electricity. It captures electricity availability over the entire day and specifically in the evening, from 6 to 10 pm.

All-day availability improved by 2022. As shown in figure 14, nationwide, 71.8 percent of Rwandan households with electricity access received at least 23 hours of electricity per day in 2022, which increased by 22.2 percentage points from 2016. Most households receiving electricity supply over such long hours use the national grid as their primary electricity source (figure 15). By locality, in both rural and urban areas, the share of households receiving electricity for 23 hours or more in the whole day increased noticeably in 2022 (figure 16).

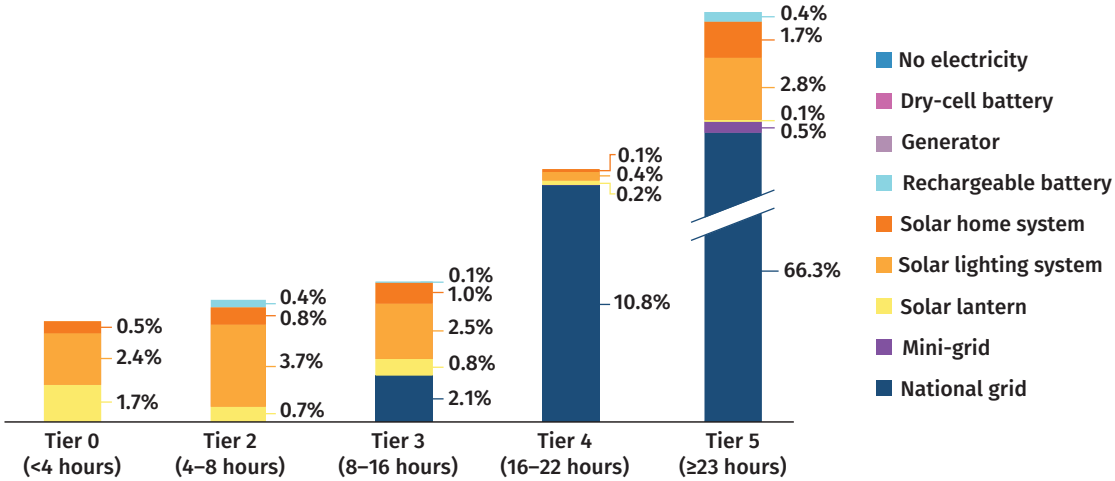
Available evening hours of electricity also increased in 2022 compared with 2016, but the improvement was smaller than for all-day availability. As shown in figure 17, in 2022, nationwide, 78.2 percent of households had 4 hours of electricity in the evening, 6.3 percentage points more than in 2016.

FIGURE 14 • Nationwide household distribution of all-day Availability Tier



Sources: Koo et al. 2018; World Bank 2022.

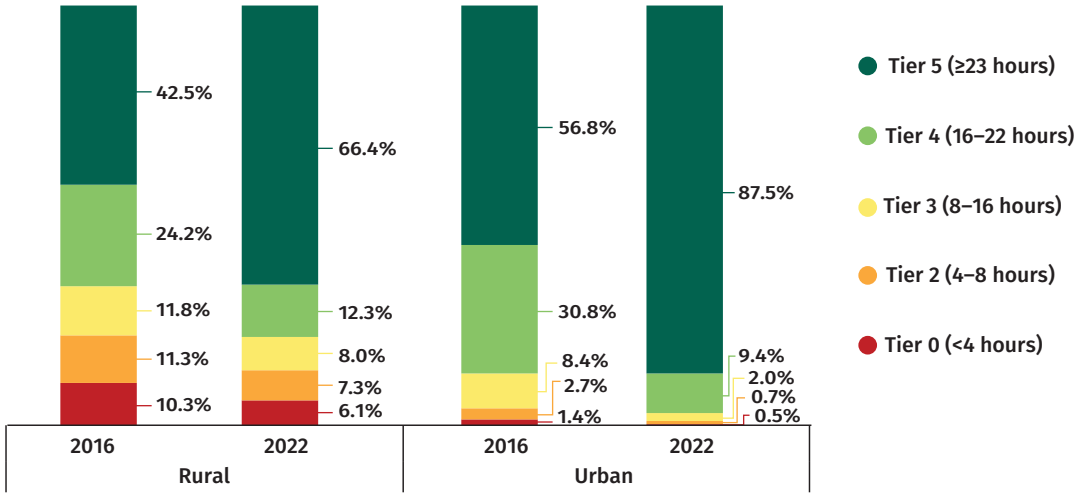
FIGURE 15 • Primary electricity source, by all-day Availability Tier (nationwide, 2022)



Source: World Bank 2022.

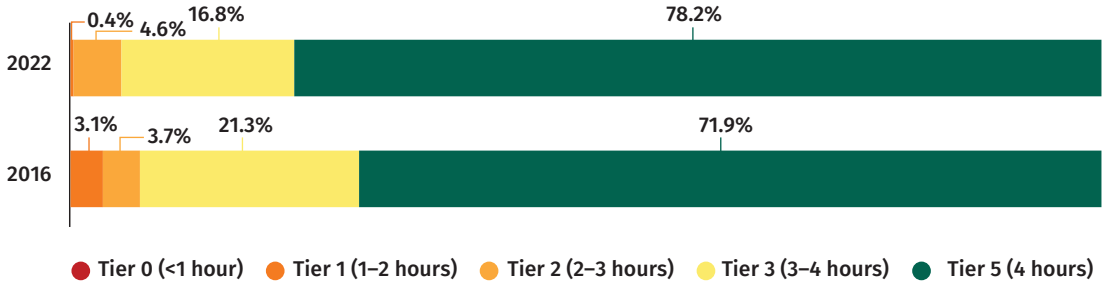
Note: A broken graph for Tier 5 to indicate the scale difference.

FIGURE 16 • Household distribution of all-day Availability Tier, by locality



Sources: Koo et al. 2018; World Bank 2022.

FIGURE 17 • Nationwide household distribution of evening Availability Tier



Sources: Koo et al. 2018; World Bank 2022.

Reliability

The Reliability attribute shows how frequently electricity from the national grid and mini-grids is interrupted in a typical week. Reliability improved substantially by 2022 compared with 2016. As shown in figure 18, by 2022, no household experienced more than 14 outages per week, and the proportion of households at Tier 5 for the Reliability attribute increased by 20.1 percentage points. Yet more than half of households still experienced 4–14 electricity interruptions, or fewer than 4 interruptions, however, lasting 2 hours in total in a typical week.

Quality

The Quality attribute captures the voltage quality of electricity from the national grid and mini-grids in the 12 months preceding the survey. Quality improved between 2016 and 2022, but not significantly. As shown in figure 19, in 2022, 14.7 percent of households nationwide experienced voltage fluctuations, a 6.2 percentage point reduction compared with 2016.

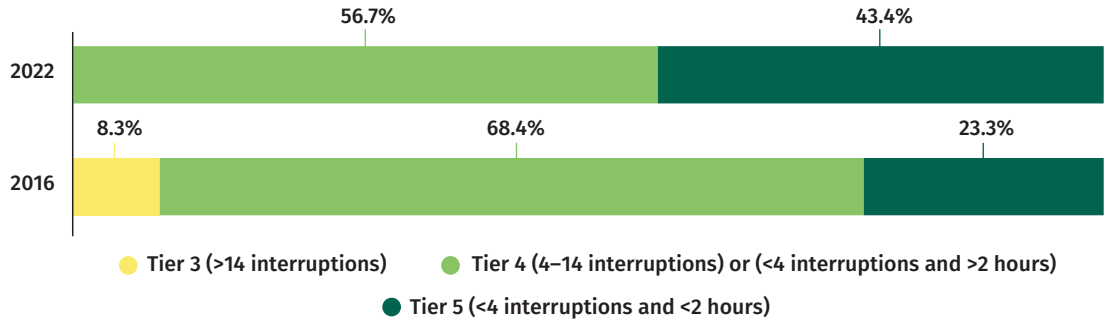
Formality

The Formality attribute tells whether households formally use their electricity from the national grid and mini-grids, paying official service providers or their authorized representatives. In Rwanda, most households formally use their electricity service (figure 20).

Health and Safety

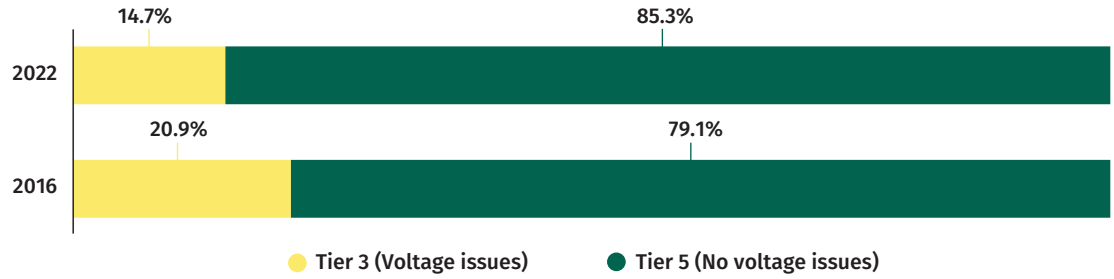
The Health and Safety attribute represents electricity safety based on households' experience of bodily injury or death from electricity in the 12 months preceding the survey. The analysis shows that electricity is generally safe in Rwanda. In 2022, 99.8 percent of households found electricity safe, a 4.5 percentage point improvement over 2016 (figure 21).

FIGURE 18 • Nationwide household distribution of Reliability Tier



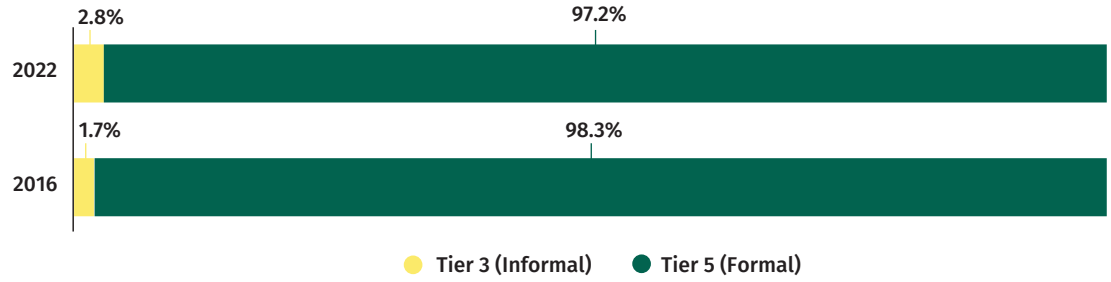
Sources: Koo et al. 2018; World Bank 2022.

FIGURE 19 • Nationwide household distribution of Quality Tier



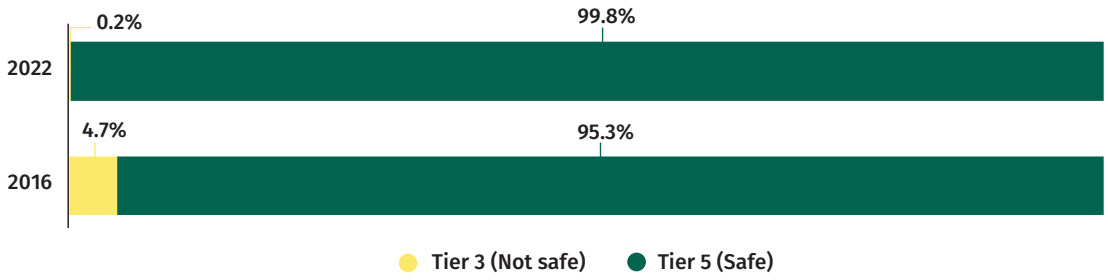
Sources: Koo et al. 2018; World Bank 2022.

FIGURE 20 • Nationwide household distribution of Formality Tier



Sources: Koo et al. 2018; World Bank 2022.

FIGURE 21 • Nationwide household distribution of Health and Safety Tier



Sources: Koo et al. 2018; World Bank 2022.

USE OF ELECTRICITY

National Grid

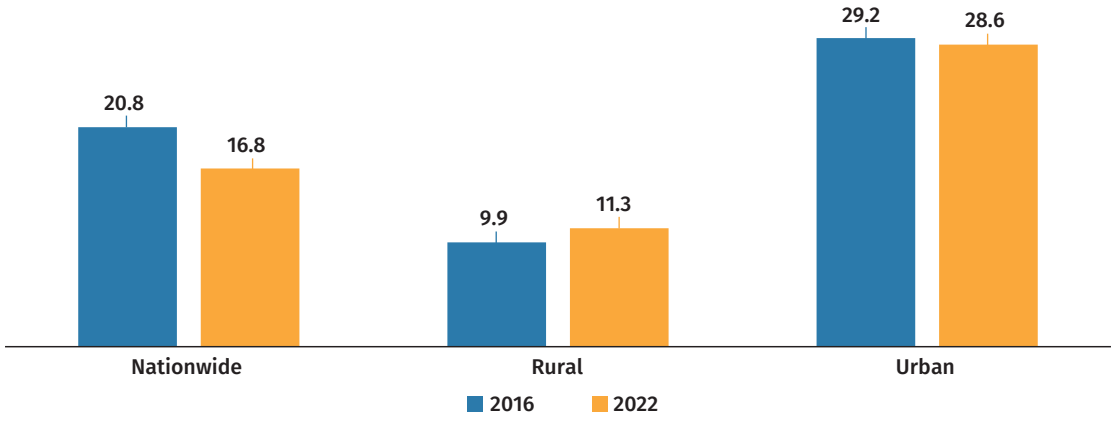
Although access to the national grid grew substantially by 2022 (figure 2), the average consumption of grid electricity remained low. In 2022, nationwide, Rwandan households consumed 16.8 kWh of electricity per month on average (figure 22), lower than the average consumption in nearby East African countries like Kenya (48.6 kWh) and Uganda (42 kWh) (Dubey et al. 2020; ESMAP, forthcoming).

The nationwide lower grid consumption in 2022 relative to 2016 was due to major grid expansion in rural areas. In 2022, 68.3 percent of grid-connected Rwandan households were rural households with low average grid consumption of 11.3 kWh (figure 22). The nationwide average grid consumption in 2022 was lowered due to the high share of rural households with low use of grid electricity.

By locality, electricity consumption shows large urban-rural disparity. In 2022, urban households consumed 2.5 times more electricity than rural households (figure 22). Across Ubudehe categories, urban households consumed more grid electricity than rural households (figure 23).

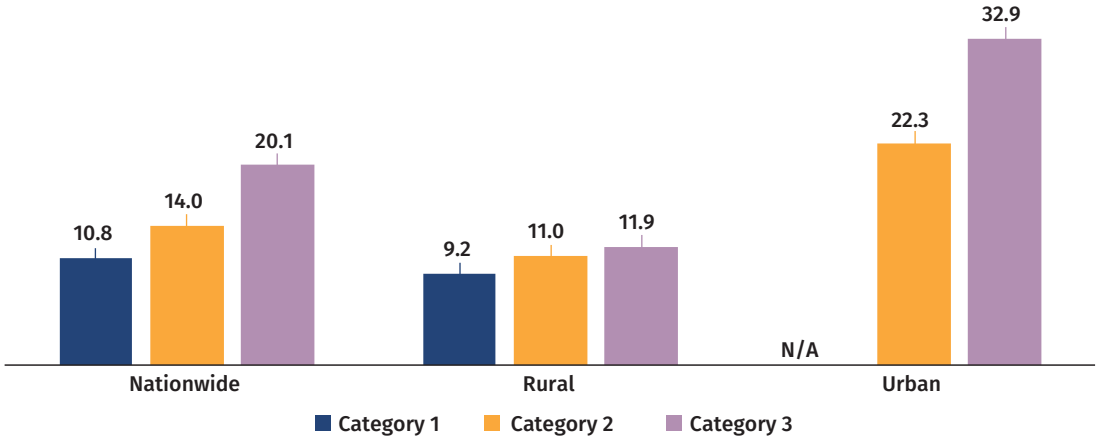
Grid consumption does not differ substantially among rural households, unlike urban households, by Ubudehe classification (figure 23). This suggests that the wealth level of rural households might not be the major factor behind their low grid consumption. Grid consumption tends to rise over time with longer periods of connection. Rural households in most Ubudehe categories have been connected to the grid for less than five years, a short duration for grid consumption to increase (figures 24 and 25).

FIGURE 22 • Monthly grid consumption, by locality (kWh)



Sources: Koo et al. 2018; World Bank 2022.

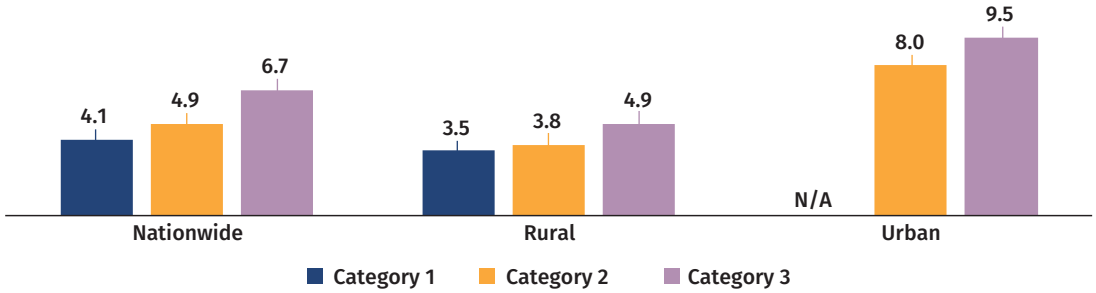
FIGURE 23 • Nationwide monthly grid consumption in 2022, by Ubudehe category and locality (kWh)



Source: World Bank 2022.

Note: The consumption of Category 1 households in urban areas was not analyzed due to the small sample size.

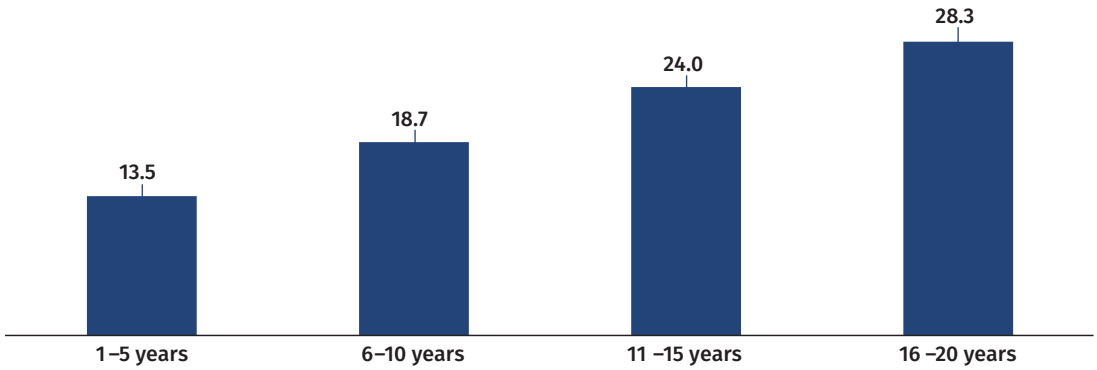
FIGURE 24 • Years of grid connection, by Ubudehe category and locality (year)



Source: World Bank 2022.

Note: The number of grid connection years for Category 1 households in urban areas was not analyzed due to the small sample size.

FIGURE 25 • Nationwide grid consumption, by years of grid connection (kWh)



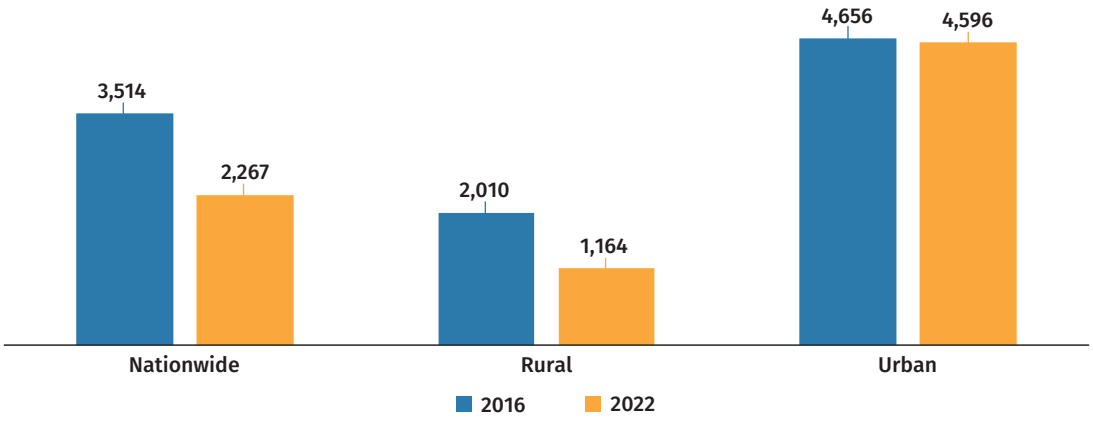
Source: World Bank 2022.

In 2022, nationwide, Rwandan households spent on average 2,267 Rwandan francs (RWF), equivalent to approximately US$2, on grid electricity (figure 26). Rural households spent RWF 1,164 (~US$1) on grid electricity, whereas urban households spent almost four times as much.

Household expenditure on grid electricity dropped significantly between 2016 and 2022, especially in rural areas (figure 26). The rural decrease may be explained by a change in the tariff scheme in 2017 from a flat rate to a block structure, with a lifeline tariff for electricity consumption below 15 kWh per month (ESRF 2019; RURA 2015, 2016). In 2022, the end-user tariff for households consuming less than 15 kWh per month was about half the tariff in 2016 (RURA 2015, 2020). Rural households consumed 11.3 kWh monthly on average in 2022, as shown in figure 22, suggesting that many would have benefited from the reduced tariff. A large share of grid-connected households are in rural areas, as mentioned earlier; the reduction in average rural grid expenditure might explain the sharp decline in the nationwide average.

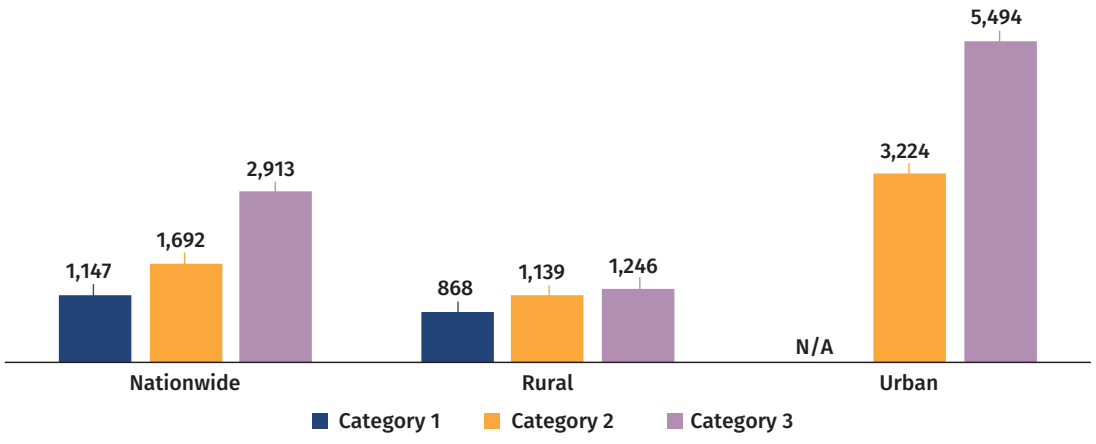
By Ubudehe category, while monthly grid expenditure does not differ substantially among rural households, it shows clear distinctions for Category 2 and 3 urban households (figure 27), corresponding to their consumption differences described in figure 23.

FIGURE 26 • Monthly grid expenditure (RWF)



Sources: Koo et al. 2018; World Bank 2022.

FIGURE 27 • Monthly grid expenditure, by Ubudehe category and locality (RWF)



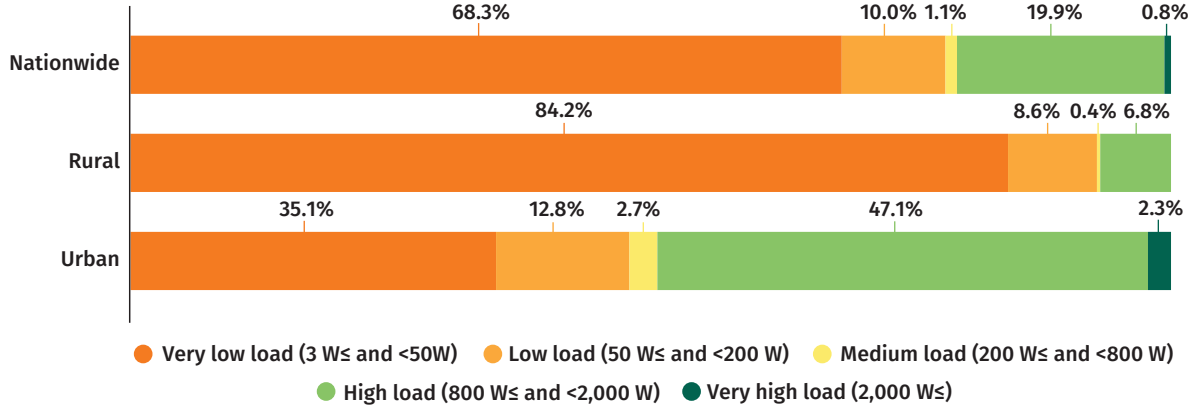
Source: World Bank 2022.

Note: The monthly grid expenditure of Category 1 households in urban areas was not analyzed due to the small sample size.

Most grid-connected households still use low-load devices and do not leverage the high capacity available from the national grid. Connecting households to the grid brings them to Capacity Tier 5, assuming 2,000 W or higher electricity capacity. While 50.7 percent of households nationwide should have access to a grid connection as shown in figure 2, the share of households using devices demanding less than 50 W as the highest-load-level appliance is 68.3 percent (figure 28). Households using appliances demanding 2,000 W or more represent only a 0.8 percent share.

This is specifically the case for rural households. Although 42.2 percent of rural households are on the grid, which would provide high-capacity electricity (figure 2), 84.2 percent use devices with load levels below 50 W as their highest-load-level appliances (figure 28). Among urban households, while it is more common to have appliances demanding higher loads, only 2.3 percent use appliances requiring 2,000 W or more. This could imply that many Rwandan households do not own appliances to leverage the capacity level, or households might suppress their appliance use because they cannot afford the expected electricity payment.

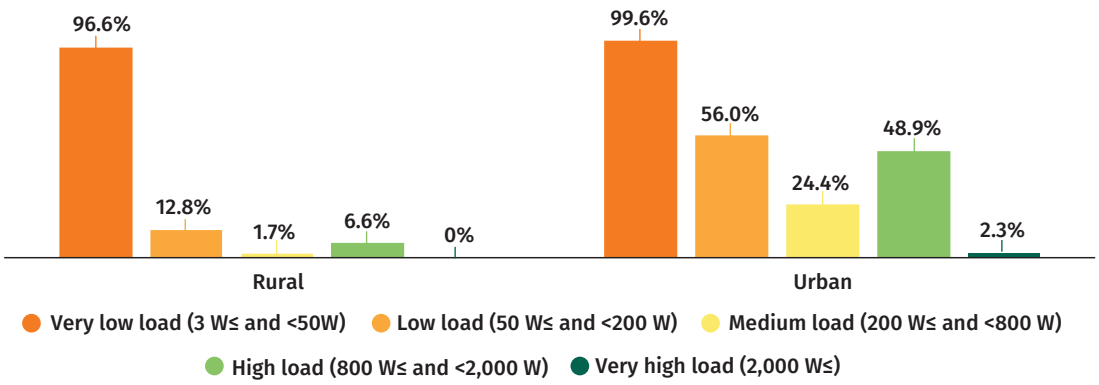
FIGURE 28 • Highest load levels of the appliances used by grid-connected households



Source: World Bank 2022.

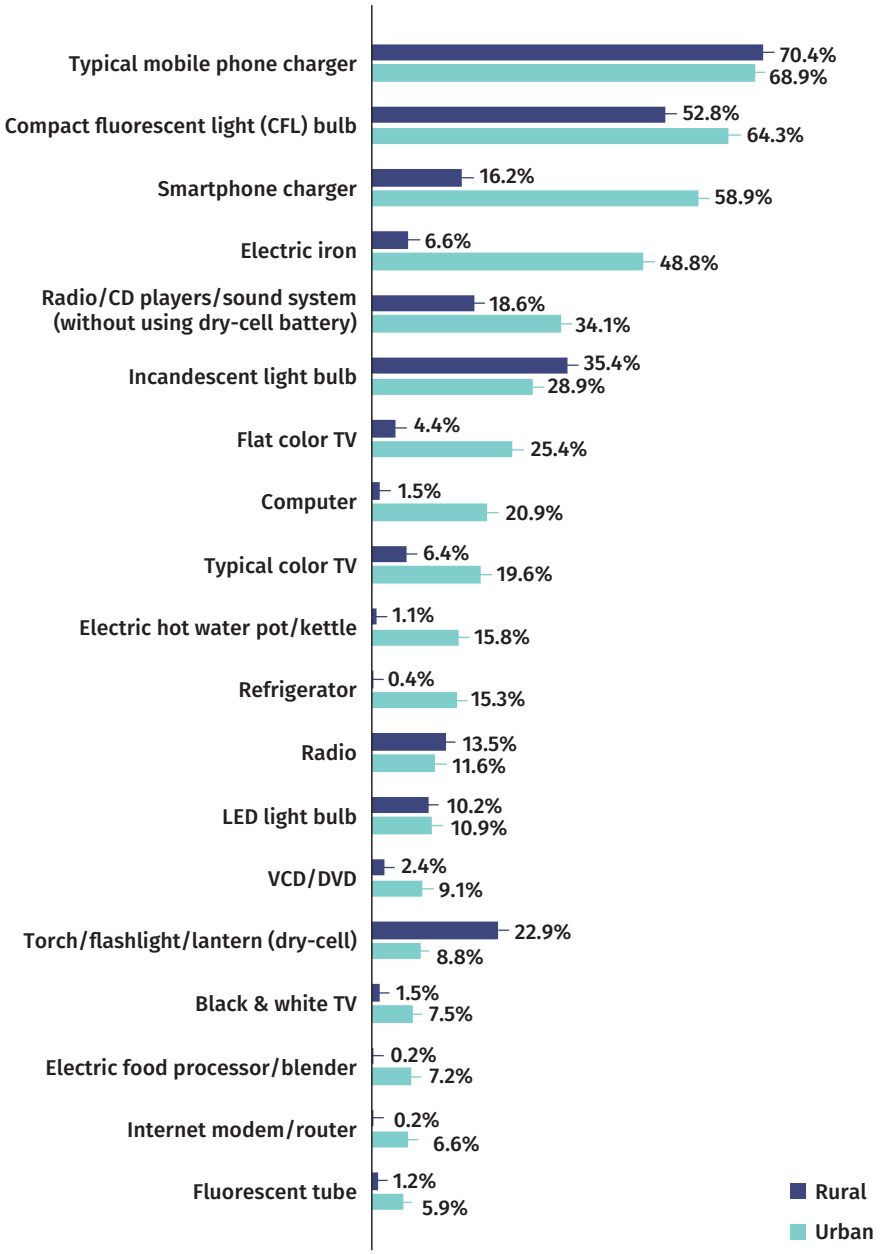
Urban households benefit more than rural households from available electricity by using more devices at varied load levels (figure 29). In both rural and urban areas, typical mobile phone chargers and compact fluorescent light bulbs are the most widely used electrical appliances (figure 30). The use of incandescent light bulbs and dry-cell battery-based flashlights is especially common among rural households, whereas the use of smartphone chargers and electric irons is high among urban households.

FIGURE 29 • Appliance use among grid-connected households, by load level



Source: World Bank 2022.

FIGURE 30 • Appliance use among households relying on the national grid as the primary electricity source, by locality



Source: World Bank 2022.

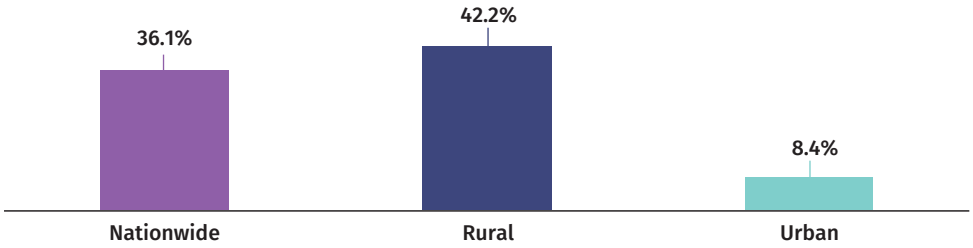
Note: LED = light-emitting diode.

2.2 IMPROVING ELECTRICITY ACCESS

PROVIDING ELECTRICITY ACCESS TO HOUSEHOLDS WITHOUT ELECTRICITY

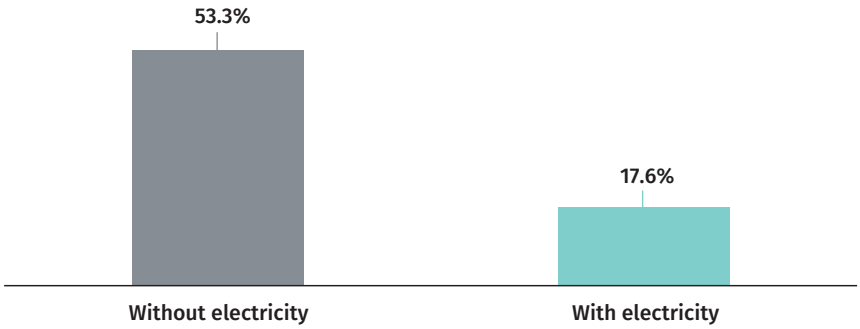
In Rwanda, a lack of electricity access is particularly a challenge in rural areas. As shown in figure 31, 42.2 percent of rural households, but only 8.4 percent of urban households, do not have access to any source of electricity. More than half of the households without electricity instead rely on dry-cell flashlights (figure 32).

FIGURE 31 • Share of households without any source of electricity



Source: World Bank 2022.

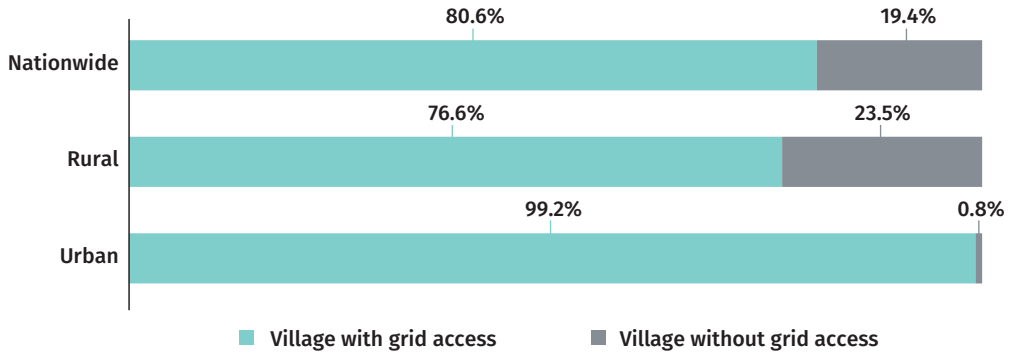
FIGURE 32 • Nationwide use of dry-cell flashlights/lanterns, by households' electricity access status



Source: World Bank 2022.

Eighteen households in each targeted village were interviewed during the survey. In this analysis, a village was assumed to have grid availability when at least 1 of the 18 surveyed households was connected to the national grid. Based on this assumption, the survey shows that, nationwide, 80.6 percent of villages have access to the grid (figure 33). However, 37.2 percent of the households in those villages are not connected to the grid, even though the villages have grid availability (figure 34). Of the households without a grid connection, 78.4 percent do not have any source of electricity, and 21.5 percent rely on off-grid solutions.

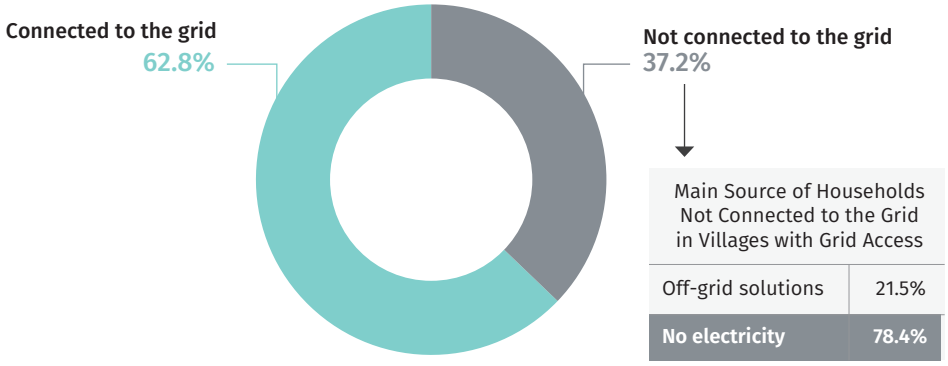
FIGURE 33 • Share of villages with grid access, by locality



Source: World Bank 2022.

**Note:* If at least 1 household out of 18 sample households in a village was connected to the grid, the village was assumed to have grid access in this analysis.

FIGURE 34 • Grid connection status of households in villages where grid access is available (nationwide)



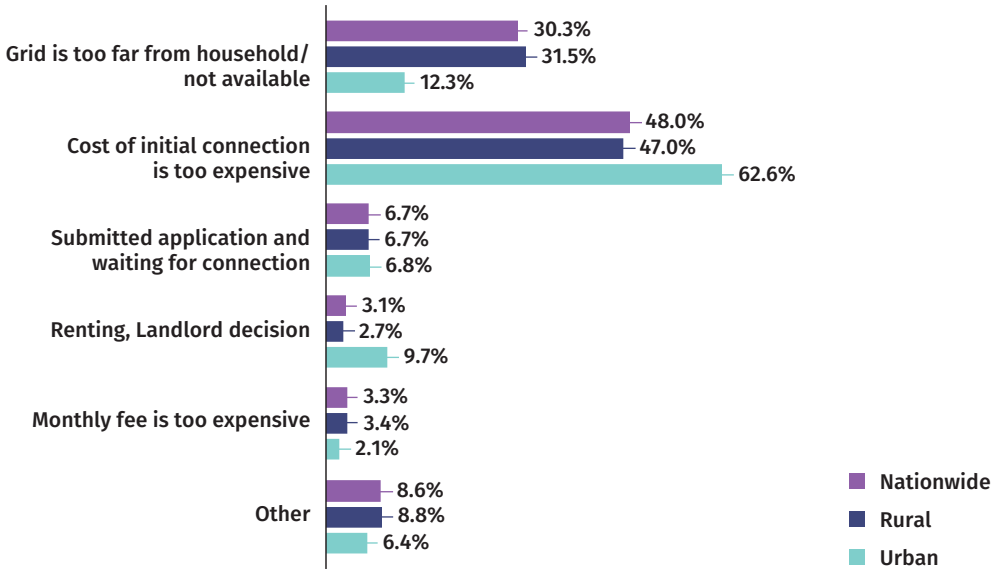
Source: World Bank 2022.

For unelectrified households in villages with grid availability, the high cost of the initial connection is the major barrier to having a grid connection (figure 35).[8] This result implies that the connection cost could still be a burden for households even though they can apply for a grid connection at no initial cost and repay the connection fee in installments along with power purchases under the connection policy from 2017 (Rwanda Energy Group 2017).[9] Households living beyond the standard connection distance of 37 meters should also pay the cost for the extension of the electricity network; remote households may thus not be able to afford the additional charges (Rwanda Energy Group 2017). It is also possible that the implementation of the connection policy is deficient, or households might not be aware of it.

[8] This is based on the same assumption as for figure 33. If at least 1 of the 18 households in a sampled village has access to the national grid, the village is considered to have grid availability.

[9] According to the connection policy, households have three options to pay the connection fees (Rwanda Energy Group 2017). The first option is to pay up front in full. The second option is a household making any down payment that it proposes and paying the remainder along with power purchases in the future. At each power purchase, 50 percent of the paid amount is used to repay the balance of the connection fee. For example, in Rwanda, households pre-pay for their electricity. Therefore, 50 percent of the pre-payment is used to repay for the connection fee, and households receive the amount of electricity for the other 50 percent of the payment. The last option is making zero down payment and repaying the connection fee along with power purchases. Again, at each power purchase, 50 percent of the amount paid is used to repay the balance of the connection fee.

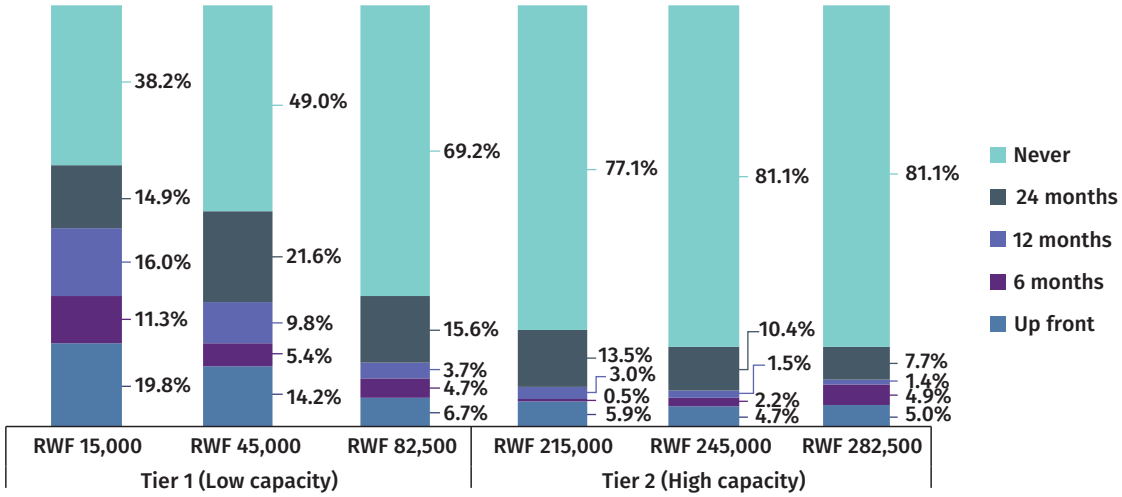
FIGURE 35 • Reasons why unelectrified households do not have a grid connection despite its availability in their villages



Source: World Bank 2022.

Households without electricity were asked whether they are willing to pay for SHSs, at different capacity levels randomly assigned to them at various price points (annex 5). Not surprisingly, households are more likely to purchase an SHS under all types of payment plans when offered lower price points (figure 36). When a high-capacity SHS of a higher price range is offered, a major share of the population is not willing to pay for it. The share of households willing to pay in installments remains low and does not change significantly when price points are high. Among households not willing to pay for the solar devices offered, 96.2 percent did not accept an offer because they could not afford the payment (table 4). To offer off-grid solar solutions to households without electricity sources, measures to relieve the price burden on them should be considered.

FIGURE 36 • Unelectrified households' willingness to pay for solar devices (nationwide)



Source: World Bank 2022.

Note: RWF = Rwandan franc.

TABLE 4 • Why households would not accept an offer of a solar device

Why not accept an offer?	
Cannot afford the payment.	96.2%
I already have electricity for my needs.	1.4%
Maintenance/servicing for the device is not available.	0.8%
Other	1.5%

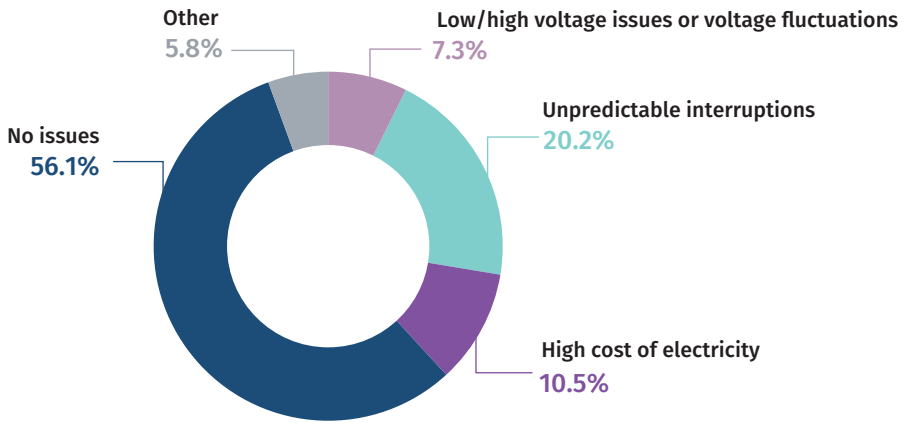
Source: World Bank 2022.

IMPROVING ACCESS TO THE NATIONAL GRID

Challenges with Electricity from the National Grid

For about half of grid-connected households, the quality of the electricity from the grid and its high costs are concerns. As shown in figure 37, 20.2 percent of households connected to the national grid reported unpredictable interruptions as their most serious concern. More than 1 out of 10 grid-connected households found electricity too expensive, and 7.3 percent of households considered voltage fluctuations to be the most serious issue.

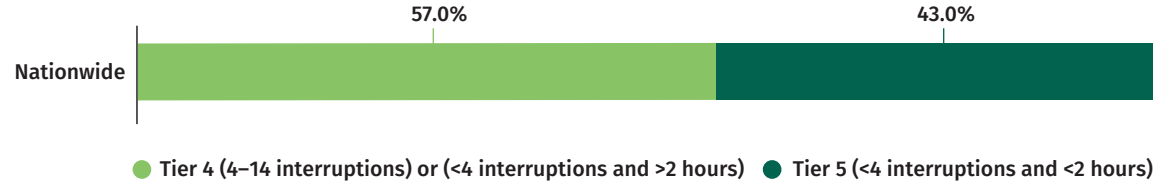
FIGURE 37 • The most serious issues with electricity from the national grid



Source: World Bank 2022.

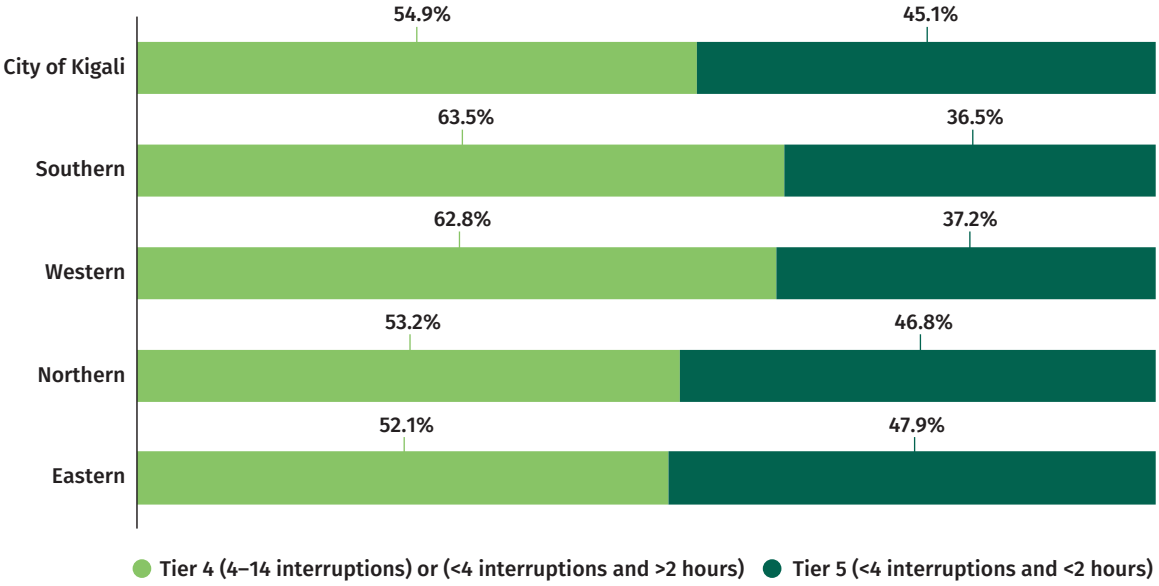
As identified in figure 37, electricity interruptions are a common issue: 57 percent of households relying on the national grid as the primary electricity source experience either 4–14 outages per week, or fewer than 4 interruptions but lasting longer than 2 hours in total per week (figure 38). Across provinces, the share of households at Tier 4 for the Reliability attribute is similar, but it is comparatively higher in the Southern and Western provinces (figure 39). Voltage fluctuation is also a concern for some households. Nationwide, about 15 percent of Rwandan households on the grid experience voltage issues, based on the Quality Tier distribution (figure 40).

FIGURE 38 • Distribution of Reliability Tier across grid-connected households



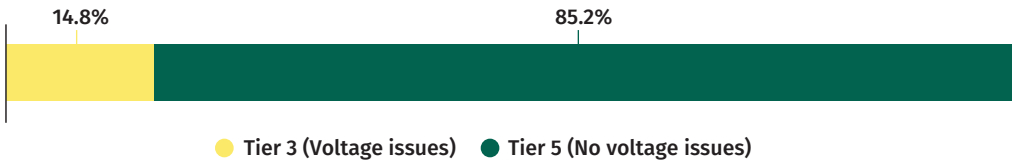
Source: World Bank 2022.

FIGURE 39 • Distribution of Reliability Tier across grid-connected households, by province



Source: World Bank 2022.

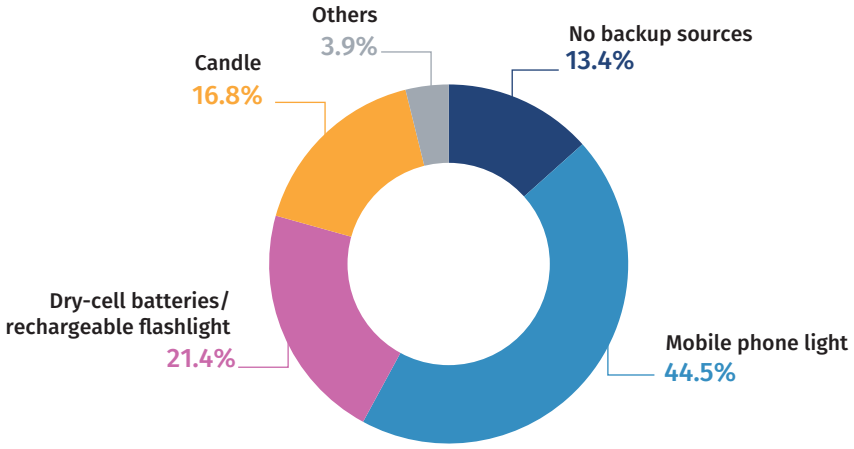
FIGURE 40 • Distribution of the Quality Tier across grid-connected households



Source: World Bank 2022.

During grid outages, households mainly rely on mobile phone lights, dry-cell lighting sources, and candles as backup sources for lighting. As shown in figure 41, nationwide, the highest share of households use mobile phone lights during grid outages, and 21.4 percent and 16.8 percent of households, respectively, use dry-cell battery/rechargeable flashlights and candles.

FIGURE 41 • Nationwide backup sources for lighting

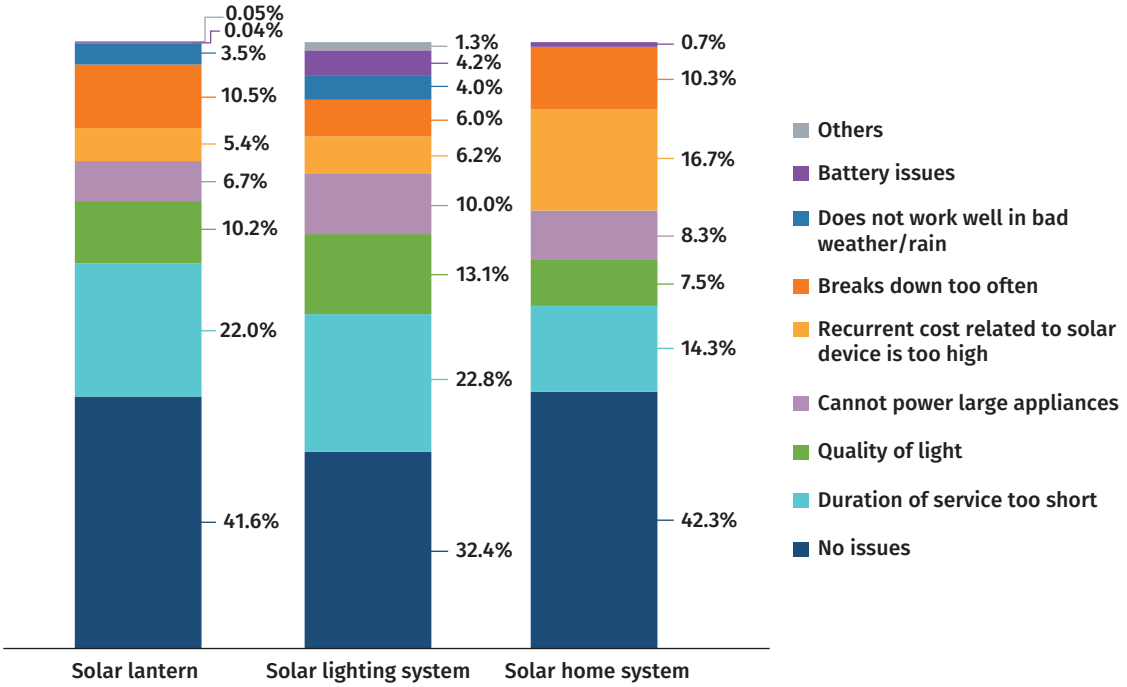


Source: World Bank 2022.

Challenges with Electricity from Off-Grid Solar Solutions

The short duration of electricity service, poor quality of light, and low power capacity are major concerns with all types of solar devices (figure 42). The share of households facing issues is slightly lower for SHSs than the other technologies, although some households using SHSs are instead burdened by the recurrent costs related to these devices.[10] Specifically, 16.7 percent of households using SHSs shoulder a cost burden, about 11 percentage points higher than for solar lanterns or SLSs.

FIGURE 42 • Issues with households' main solar devices



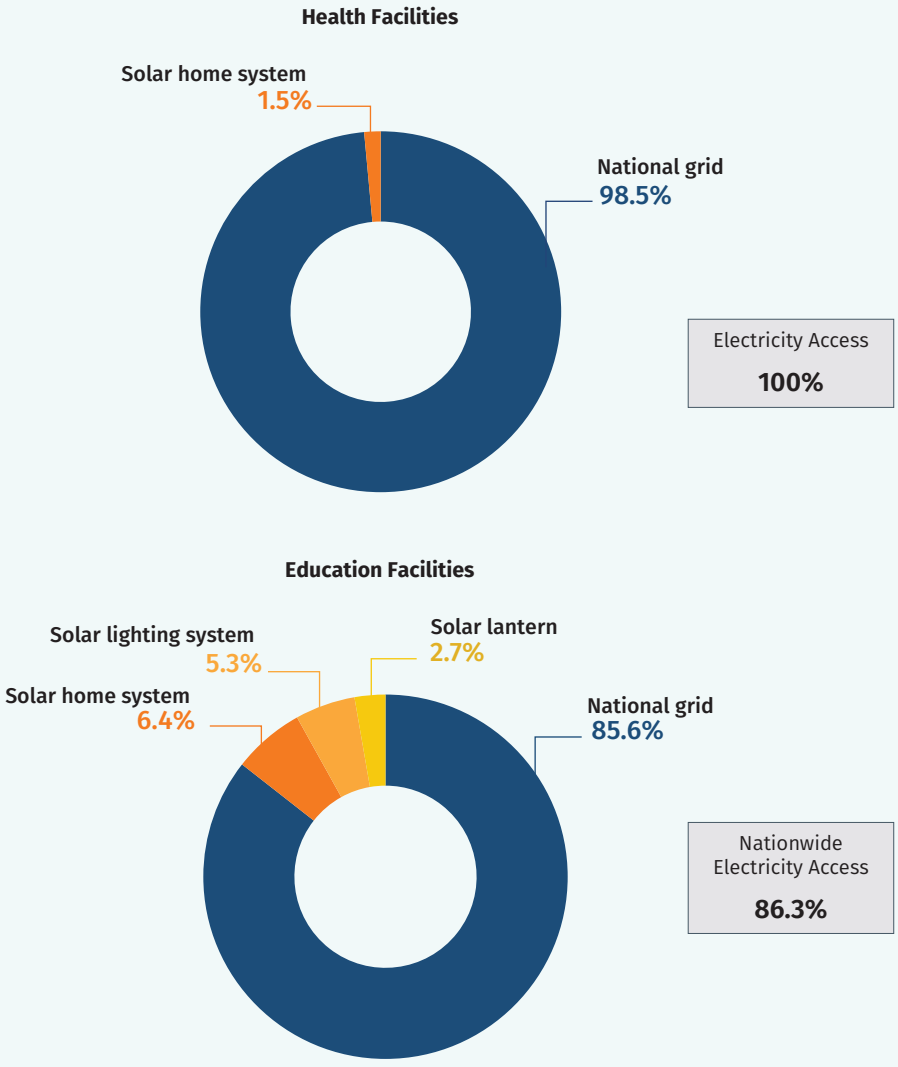
Source: World Bank 2022.

[10] The survey question did not specify the recurrent costs.

BOX 5 • ELECTRICITY ACCESS OF RWANDA'S PUBLIC INSTITUTIONS

Rwanda's education and health facilities have overall high electricity access, although access is lower among education centers. As shown in figure 43, nationwide, 100 percent of health facilities are electrified; the access rate is 13.7 percentage points lower among education facilities. The use of grid electricity is prevalent among both types of public institution, whereas off-grid solar solutions are used more by education facilities. Solar technologies are used by 14.4 percent of Rwanda's schools, a share 12.9 percentage points higher than that among health facilities.

FIGURE 43 • Electricity access of public institutions, by technology



Source: World Bank 2022.

2.3 POLICY RECOMMENDATIONS

EXPAND RURAL ELECTRIFICATION

Electricity access improved significantly in Rwanda between 2016 and 2022, especially in rural areas. However, the survey shows a persistent, large urban-rural access disparity. To close the gap, electrification of rural areas should be targeted.

INCREASE ACCESS TO THE NATIONAL GRID IN PROVINCES OTHER THAN THE CITY OF KIGALI

As noted earlier, electricity access and grid connections are lagging in all areas outside the City of Kigali. This suggests a need to distribute future grid expansions to areas outside the City of Kigali, besides expanding electricity access particularly in the Southern, Western, and Northern provinces, where access is relatively low.

IMPROVE THE RELIABILITY OF GRID ELECTRICITY

The survey demonstrates that nationwide, 57 percent of grid-connected households experience frequent outages in a week. More than one out of five grid-connected households reported electricity interruptions as the most serious issue with their grid electricity. These findings underscore the need to improve the connection quality of the national grid.

EVALUATE THE COST OF CONNECTING TO THE NATIONAL GRID

The survey shows the high cost of the initial grid connection as the most important barrier to having a grid connection for almost half of the unelectrified households in villages with grid availability. Households could still find the connection cost high, even if they can spread their payment under the connection policy from 2017. For remote households, the additional charges for network extension could be a burden. To understand and identify major challenges to households, all aspects of the cost burden should be examined further.

Also, the implementation of the connection policy from 2017 should be reviewed and evaluated. Households might have reported the cost barrier to a grid connection because the policy's implementation was deficient. It could be that the households failed to benefit from the policy because it may have been insufficiently advertised. The policy's implementation should be assessed and improved as needed.

ADDRESS THE HIGH COST OF ELECTRICITY

Based on the survey, the high cost of grid electricity was identified as the most serious challenge by more than 1 out of 10 grid-connected households. To reduce the cost of electricity, Rwanda's least-cost power generation plan should be implemented.

3. ACCESS TO MODERN ENERGY COOKING SERVICES

3.1 ASSESSING HOUSEHOLDS' ACCESS TO MODERN ENERGY COOKING SERVICES

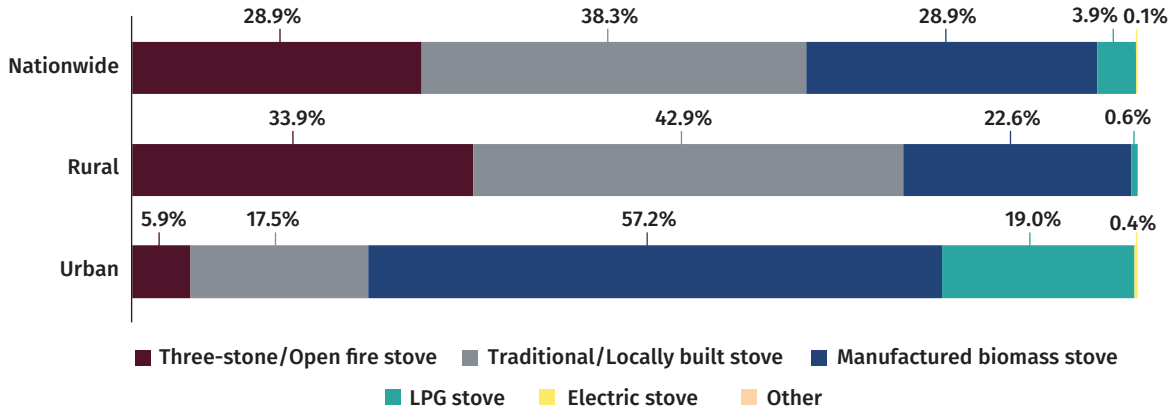
ACCESS TO MODERN ENERGY COOKING BY TECHNOLOGY

Nationwide

In Rwanda, clean cooking practices are still rare. Nationwide, the largest share of households cook with either three-stone/open-fire stoves or traditional/locally built stoves (figure 44). Clean cooking solutions such as liquefied petroleum gas (LPG) stoves and electric stoves are barely used.[11]

Stove choices show large urban-rural differences. While three-stone/open-fire stoves and traditional stoves are more prevalent as primary cookstoves among rural households, more than half of urban households use more advanced manufactured biomass stoves, and 19 percent use LPG stoves (figure 44). The penetration of LPG stoves increased significantly in 2022 compared with 2016 when only 1.7 percent of urban households used them (figure 45).

FIGURE 44 • Primary cookstove, by locality (2022)

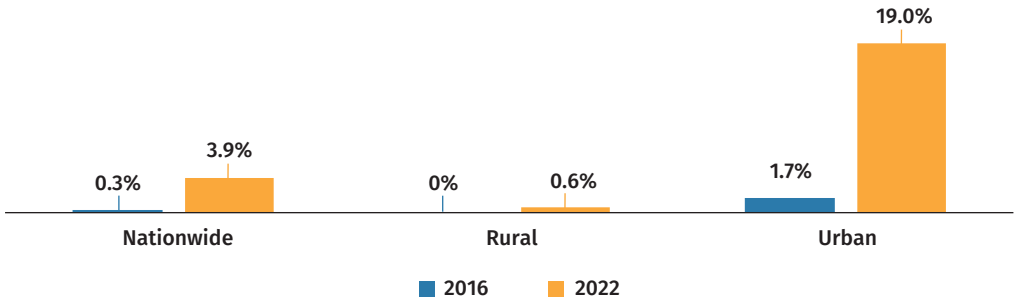


Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

[11] In the survey, the options for primary stove were three-stone/open-fire stove, traditional/locally built stove, manufactured biomass stove, kerosene stove, LPG stove, electric stove, solar cooker, or any other. The survey showed that no Rwandan households use solar cookers.

FIGURE 45 • Use of LPG stoves



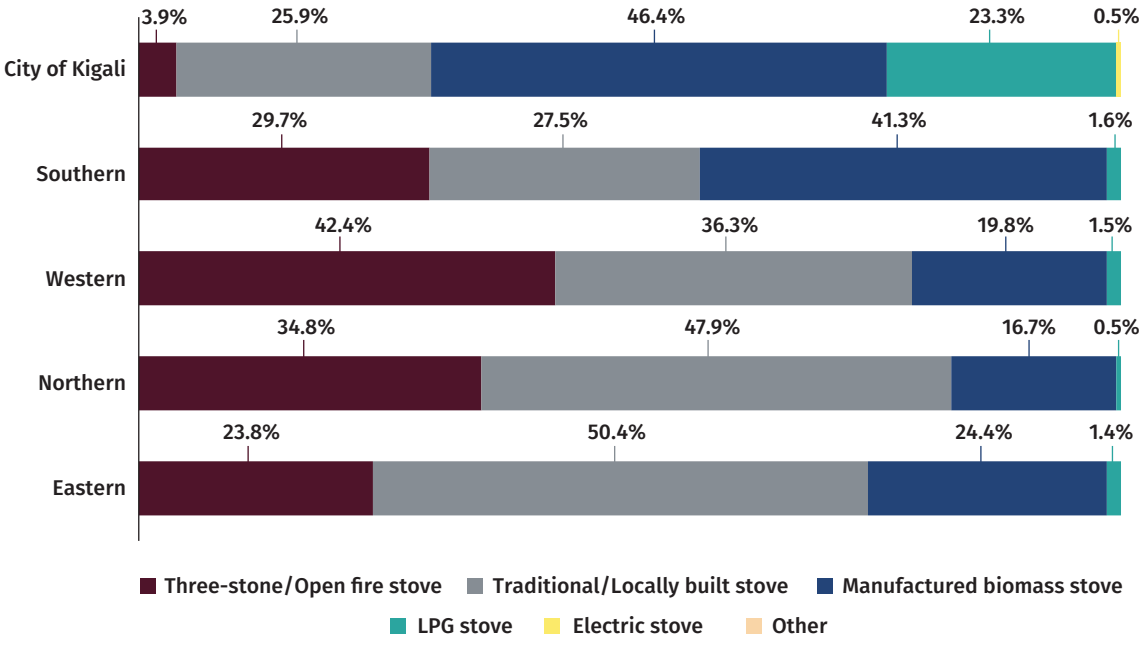
Sources: Koo et al. 2018; World Bank 2022.

Note: LPG = liquefied petroleum gas.

By Province

The use of clean stoves is limited to the City of Kigali.[12] As shown in figure 46, 23.8 percent of households in the City of Kigali use LPG stoves or electric stoves as their primary cookstoves, and 46.4 percent use manufactured biomass stoves. By contrast, in all other provinces, three-stone/open-fire stoves and traditional stoves are predominant, and the use of clean stoves is insignificant.

FIGURE 46 • Primary cookstove, by province



Source: World Bank 2022.

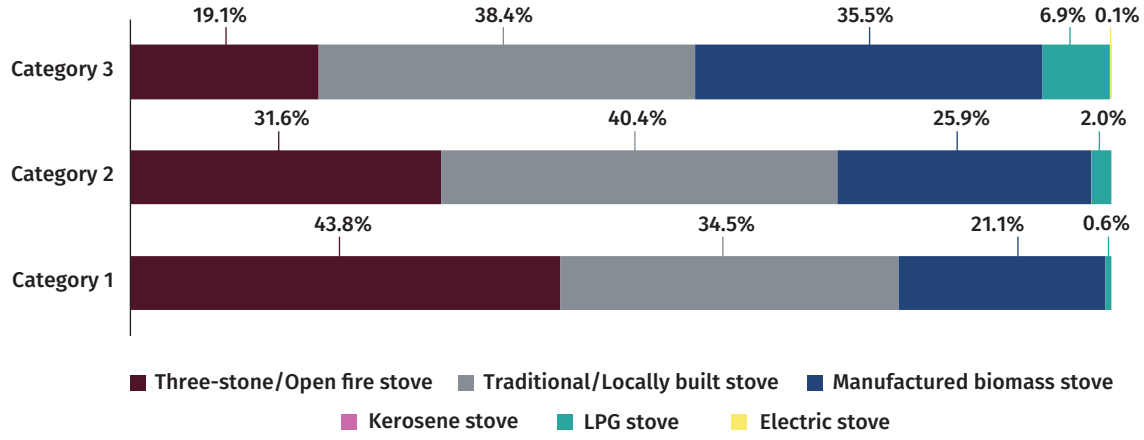
Note: LPG = liquefied petroleum gas.

[12] Kigali has been at the center of the clean fuel transition. Rwanda's Ministry of Environment banned the supply and use of charcoal in Kigali in 2020 (Nkurunziza 2020), and Kigali has been one of the priority targets for the Government of Rwanda for the accelerated rollout of LPG (Global LPG Partnership, KfW, and European Union 2021).

By Ubudehe Category

The use of clean stoves is positively correlated with Ubudehe classifications. The use of LPG stoves and manufactured biomass stoves as the primary cookstoves tended to be higher among households in higher Ubudehe categories (figure 47), whereas three-stone/open-fire stoves and traditional stoves were more adopted by households in lower Ubudehe categories.

FIGURE 47 • Primary cookstove type, by Ubudehe category

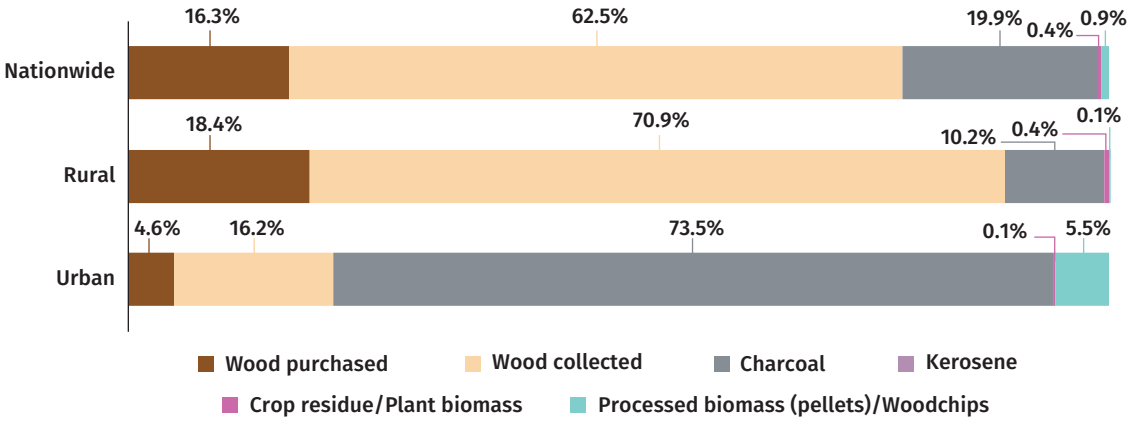


Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

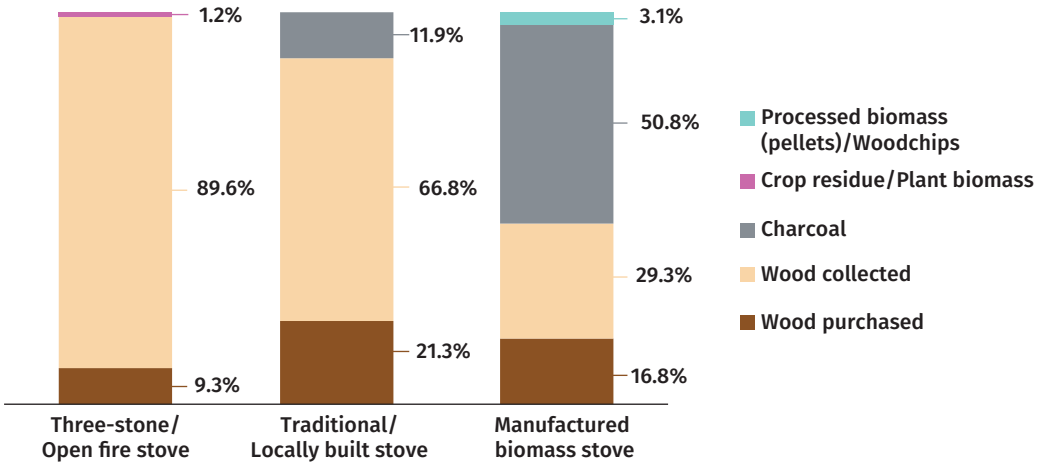
Rural households heavily consume wood, whereas charcoal is widely consumed in urban areas (figure 48). The use of wood is high among rural households, where three-stone/open-fire stoves and traditional stoves are more prevalent, as shown in figure 44, which mainly burn firewood (figure 49). A high share of rural households collect wood rather than purchase it (figure 48). On the other hand, in urban areas, where manufactured biomass stoves are more prevalent, charcoal consumption is high (figures 48 and 49).

FIGURE 48 • Fuels for primary stoves, by locality



Source: World Bank 2022.

FIGURE 49. Fuel use, by primary stove

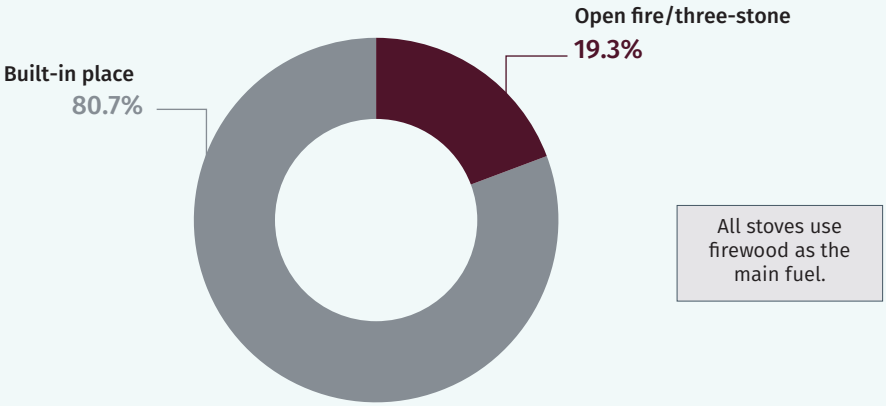


Source: World Bank 2022.

BOX 6 • USE OF STOVES AMONG RWANDAN EDUCATION FACILITIES

Nationwide, 98.8 percent of Rwandan schools preparing meals use just one cookstove (World Bank 2022). Firewood-burning built-in-place stoves are predominant, used by 80.7 percent of these schools (figure 50). Regardless of stove type, all education facilities use firewood for their stoves. Schools spend on average RWF 129,087 (~US$126) monthly on firewood, and the average consumption is 14.4 steres (World Bank 2022).

FIGURE 50 • Primary cookstove of education facilities (nationwide)

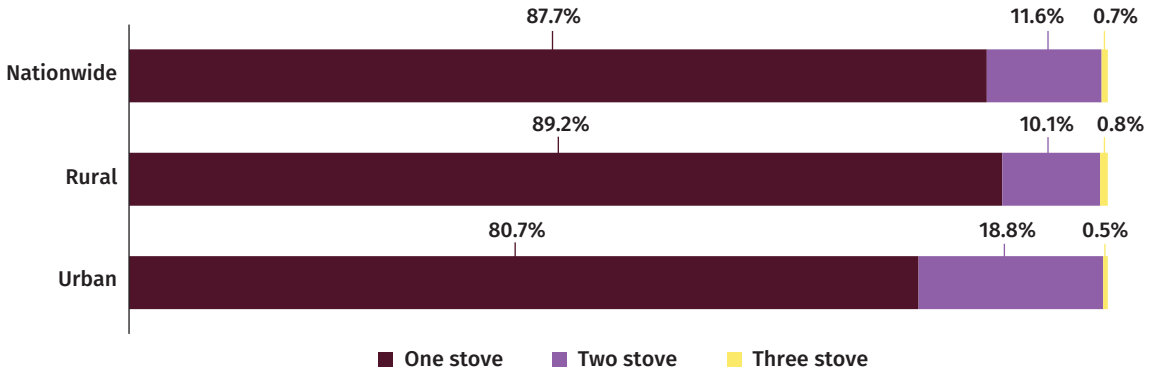


Source: World Bank 2022.

STOVE STACKING

Households' stacking more than one cookstove could reflect their desire to transition to improved stoves or a need for backup cookstoves. Stove stacking is not common in Rwanda. Most households own just one stove. Only 11.6 percent of households have two cookstoves stacked, and a negligible share stack three stoves (figure 51). Stacking is more common in urban areas than rural areas. The share of urban households with two stoves is roughly two times higher than the share of rural households with two.

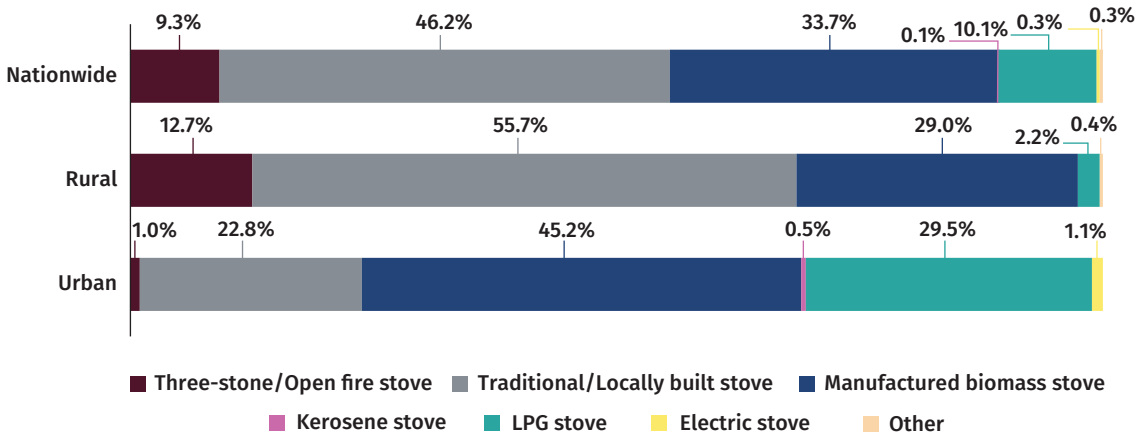
FIGURE 51 • Number of cookstoves stacked, by locality



Source: World Bank 2022.

Nationwide, households with two stoves most commonly stack traditional stoves and manufactured biomass stoves (figure 52). LPG stoves are stacked by 10.1 percent of households. The highest share of rural households stack traditional stoves, whereas urban households most commonly keep aside manufactured stoves and LPG stoves.

FIGURE 52 • Stacked stoves of households with two stoves



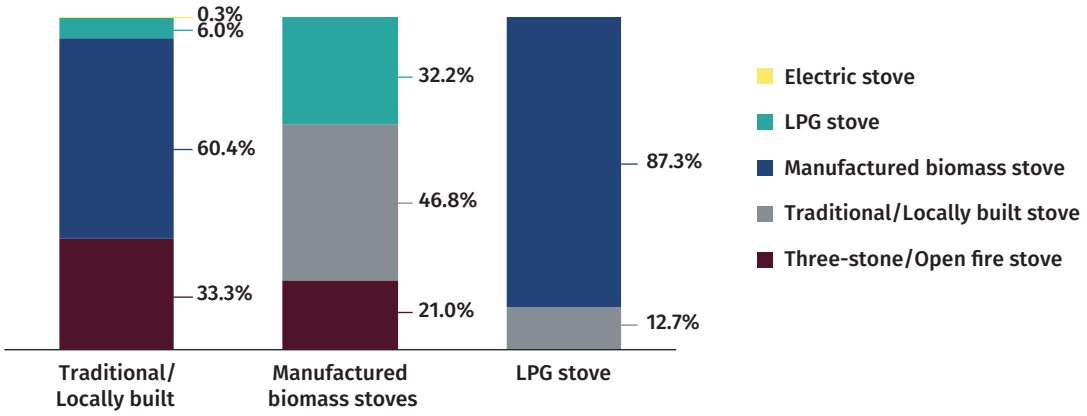
Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

While some households with two cookstoves transitioned to an improved cookstove, the high fuel cost led some to continue using a high-emission, inefficient stove. As shown in figure 53, 60.4 percent of households stacking traditional stoves use manufactured biomass stoves as their primary cookstove. In this case, the households transitioned to an improved cookstove. However, 33.3 percent use three-stone/open-fire stoves as their primary cookstove, which are likely to be unhealthy and less-efficient. Among households keeping aside manufactured biomass stoves, almost one-third transitioned to cleaner LPG stoves as their primary cookstoves, whereas the rest relied on traditional cookstoves. All households stacking LPG stoves use a less-efficient stove as their primary cookstove.

High fuel cost is the most important reason households owning an improved cookstove continue using a high-emission, less-efficient one. The survey shows that all households stacking traditional stoves and LPG stoves, and 99.6 percent of households stacking manufactured biomass stoves do not use them most of the time due to the expensive fuel. This suggests that to increase clean cooking in households, it will be crucial to identify inefficiencies that drive up fuel costs and/or provide financial assistance to reduce the burden from fuel price.

FIGURE 53 • Primary stoves of households with two stoves, by stove kept aside (nationwide)



Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

EVALUATING ACCESS TO MODERN ENERGY COOKING USING THE MULTI-TIER FRAMEWORK

In the analysis using the Multi-Tier Framework (MTF), access to clean cooking among Rwandan households is measured using four attributes (shown in figure 54). The lowest tier across the four attributes becomes a household's final tier classification, or the aggregate Cooking Tier. If a household scores Tier 2 or higher in all cooking attributes, then its final tier will also be Tier 2 or above. Being at Tier 2 or higher indicates access to clean cooking services (aggregate Tiers 4 and 5) or at least improved cooking services in the transition to clean cooking (aggregate Tiers 2 and 3).[13] Households at Tiers 0 and 1 are not considered to have access to clean cooking services since their health and safety are critically threatened by cooking activities. The tier distributions of the attributes to evaluate access to clean cooking were not compared between 2016 and 2022 because the tier computation methodologies were unique to each analysis.

[13] Tier 2 is no longer promoted through the World Bank programs starting from 2024.

FIGURE 54 • MTF Cooking Tier matrix for the Rwanda energy survey analysis

ATTRIBUTES		TIER SCORE					
		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Exposure	International Organization for Standardization's voluntary performance targets on emissions (default ventilation) $PM_{2.5}$ (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 $PM_{2.5}$ (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 $PM_{2.5}$ (mg/MJd) CO (g/MJd)	>550 >9.9	≤550 ≤9.9	≤252 ≤5.5	≤115 ≤3.7	≤32 ≤2.2	≤2 ≤1.4
Convenience	Fuel acquisition & preparation time *(hr/week)*	-	≥7	<7	<3	<1.5	<0.5
	Stove preparation time *(min/week)*	-		≥10	<10	<5	<2
Safety *(Harm from stove)*		Death	-	Serious	Minor	-	None
Availability *(Fuel availability)*		-		Rarely	Sometimes	Mostly	Always

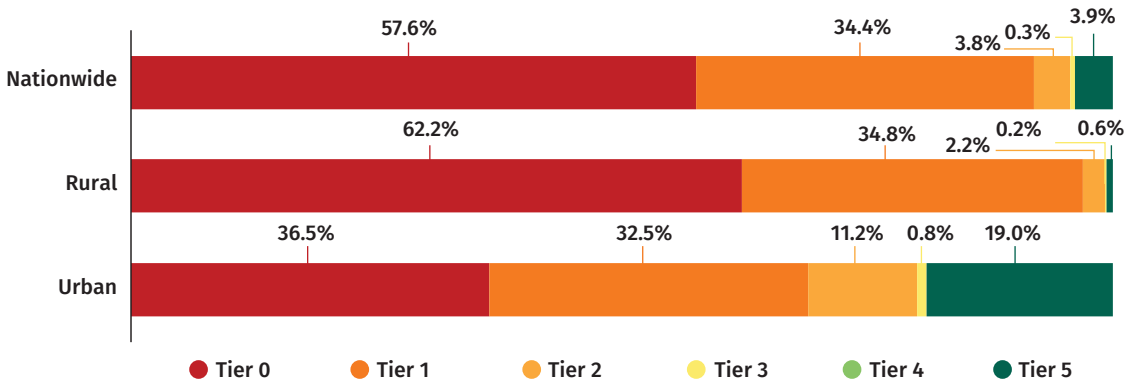
Source: ESMAP 2020.

Note: The tier score range is unique for each attribute. A gray cell or block refers to a tier or tiers that do not need to contribute to the relevant score range. For example, a binary/bipolar situation will require only two tiers, and hence, the apparently discontinuous or partial sequences of tiers illustrated. The Efficiency and Affordability attributes are excluded from the table since they were not included in the analysis of the survey in Rwanda.
hr = hour; min = minutes.

Aggregate Cooking Tier

As of 2022, the majority of Rwandan households did not have access to clean cooking. Nationwide, 92 percent of households were in aggregate Cooking Tiers 0 and 1, suggesting that most households were exposed to threats from unhealthy cooking practices (figure 55). This highlights the need to advertise healthy cooking practices and expand improved cookstove options for households nationwide. More rural households, which commonly use firewood-burning three-stone/open-fire stoves and traditional stoves, lack access to clean cooking than urban households. Among rural households, 97 percent without access to clean cooking are at Tiers 0 and 1; among urban households, the share is 28 percentage points lower. Urban areas have a larger share of households at aggregate Cooking Tier 5 than do rural areas.

FIGURE 55 • Household distribution of aggregate Cooking Tier, by locality (2022)



Source: World Bank 2022.

By Attribute

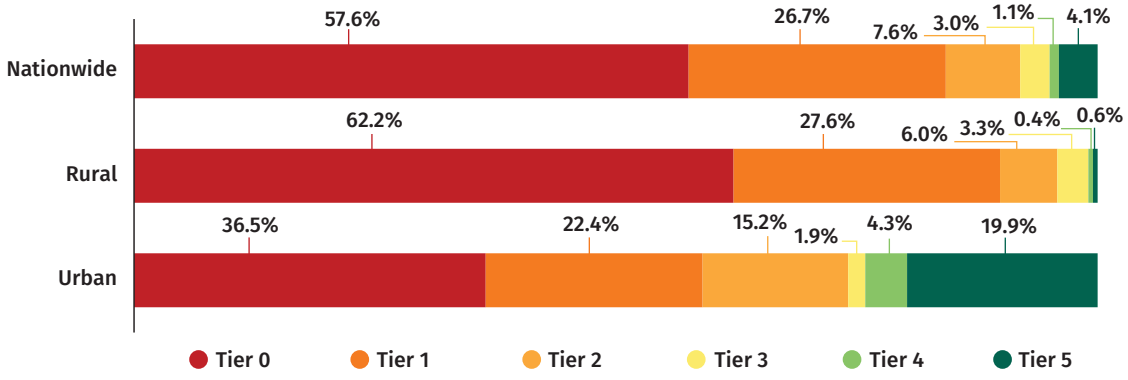
Cooking Exposure

The Exposure attribute captures the health impacts of cooking activities based on cookstove emissions and ventilation in cooking areas. Households cooking indoors using high-emission stoves (for example, three-stone/open-fire stoves and traditional biomass stoves) without proper ventilation are placed in low tiers of this attribute.

The analysis shows that cooking activities jeopardize the health of most Rwandan households, who are exposed to a high-pollutant cooking environment. Nationwide, about 84 percent of households are at Tiers 0 and 1 for the Exposure attribute (figure 56). The survey demonstrates that these households commonly cook with three-stone/open-fire stoves or traditional stoves (figure 57) with no ventilation system (for example, no chimneys or hoods) (figure 58).

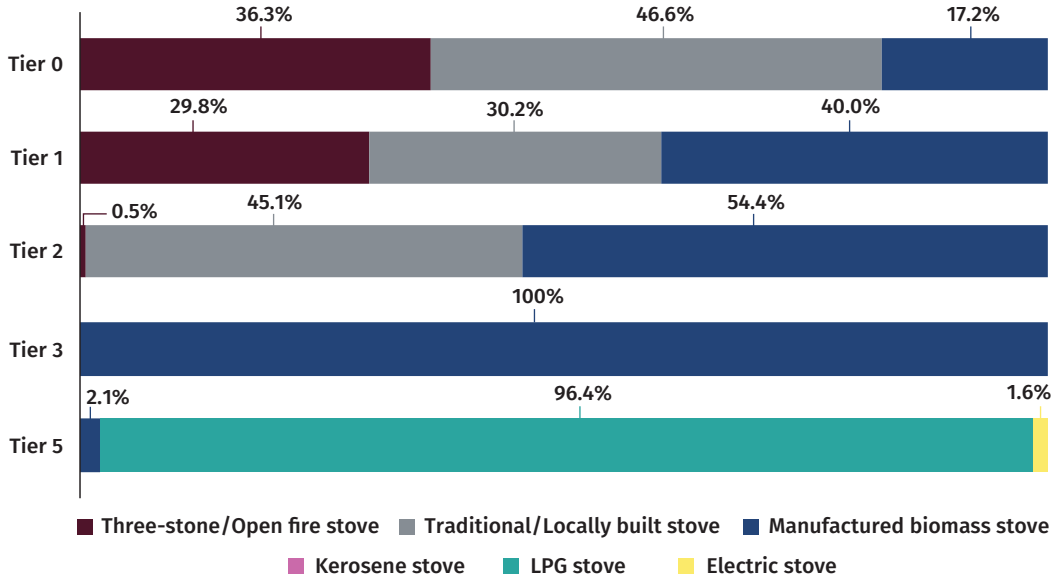
About one-fifth of urban households are at Tier 5, likely due to their use of clean stoves (figures 44 and 56). Nevertheless, 58.9 percent of urban households are at Tiers 0 and 1, showing that the highest share of urban households are exposed to harmful cooking environments. An 89.8 percent share of rural households are in the same tier range.

FIGURE 56 • Nationwide household distribution of Exposure Tier (2022)



Sources: Koo et al. 2018; World Bank 2022.

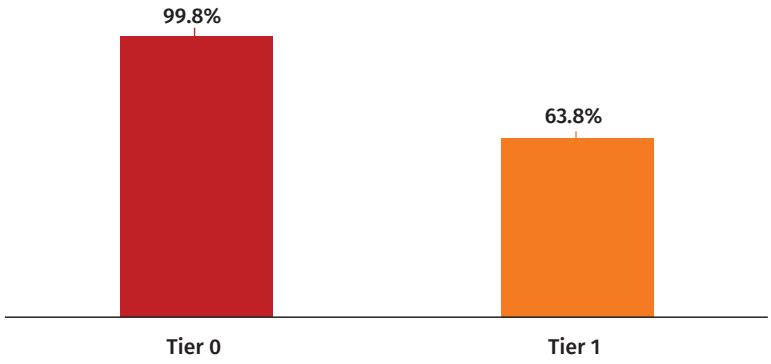
FIGURE 57 • Households' primary cookstoves, by Exposure Tier (2022)



Source: World Bank 2022.

Note: Primary stove distribution for Exposure Tier 4 not available due to limited data. LPG = liquefied petroleum gas.

FIGURE 58 • Households in Exposure Tiers 0 and 1, cooking indoor without any ventilation systems



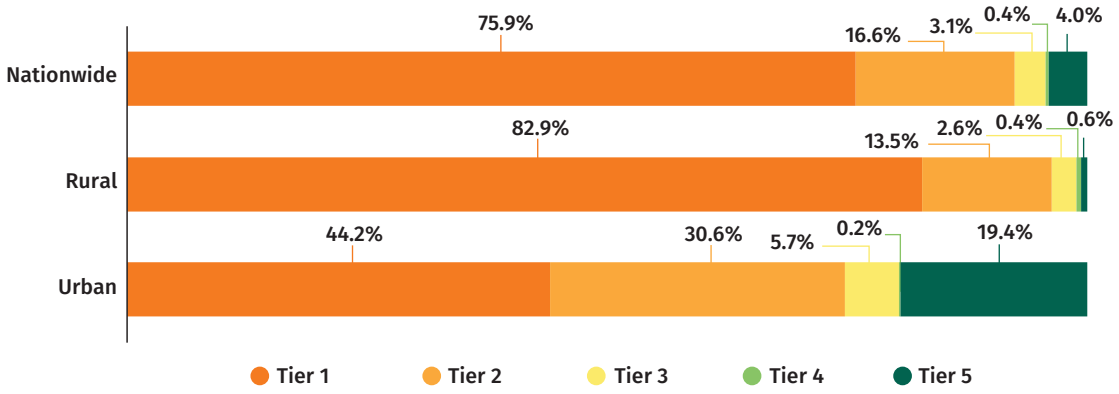
Source: World Bank 2022.

Note: Ventilation systems in this analysis do not include windows.

Convenience

This attribute assesses the convenience of households' cooking activities. The assessment is based on preparation time, including acquiring fuel and preparing the cookstove. For most Rwandan households, fuel and stove preparation are time-consuming activities. A high proportion of Rwandan households, especially in rural areas, spend seven hours or more per week on acquiring fuel and preparing their stoves (figure 59). The nationwide high share of Tier 1 households for the Convenience attribute would be explained by rural households' heavy reliance on three-stone/open-fire stoves and traditional stoves, which use collected wood as the fuel. Cooking is more convenient in urban than in rural areas; a higher share of urban households are above Tier 1. Urban households' lower reliance on stoves using collected wood and higher use of LPG stoves are the likely reasons for their comparatively higher Convenience Tier.

FIGURE 59 • Household distribution of Convenience* Tier, by locality (2022)



Source: World Bank 2022.

* Convenience Tier Chart

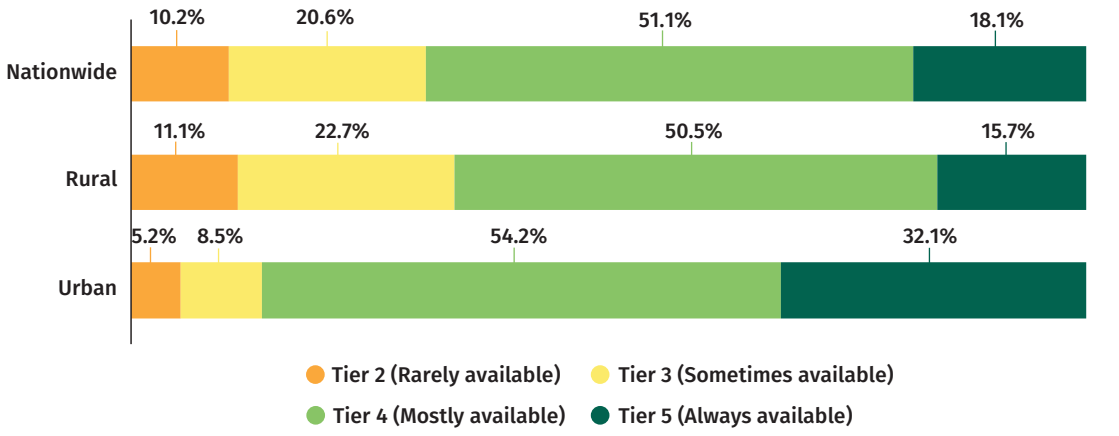
		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Convenience	Fuel acquisition & preparation time *(hr/week)*	-	≥7	<7	<3	<1.5	<0.5
	Stove preparation time *(min/week)*	-		≥10	<10	<5	<2

Source: Bhatia and Angelou 2015.

Fuel Availability

This attribute captures the availability of fuel among households using three-stone/open-fire stoves and traditional/locally built stoves in the 12 months preceding the survey. Fuel availability is more of an issue for rural households, among which firewood use is high. As shown in figure 60, fuel is rarely or sometimes available for 33.8 percent of rural households. The share is 13.7 percent among urban households.

FIGURE 60 • Household distribution of Availability Tier, by locality (2022)

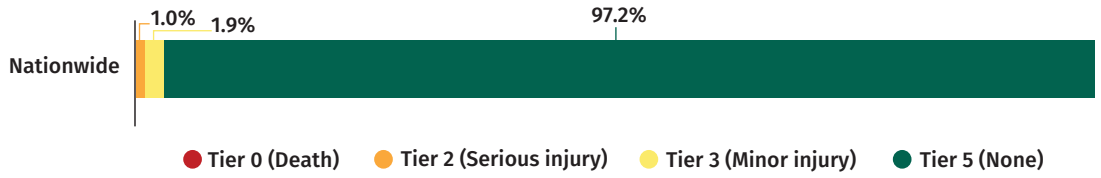


Source: World Bank 2022.

Safety

The Safety attribute focuses on the primary cookstove. The safety assessment is based on records of any harm or injury in the 12 months preceding the survey. In 2022, cookstoves were generally safe in Rwanda. Nationwide, most households are at Tier 5 for the Safety attribute (figure 61).

FIGURE 61 • Household distribution of cooking Safety Tier, by locality (2022)



Source: World Bank 2022.

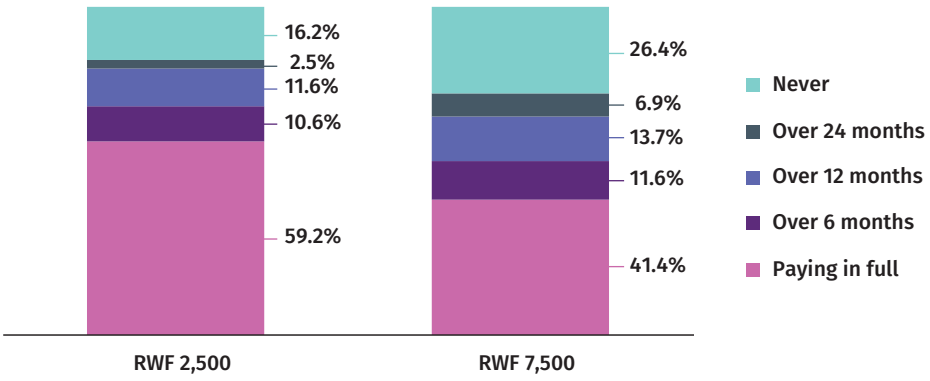
3.2 IMPROVING ACCESS TO MODERN ENERGY COOKING

EXPANDING THE USE OF IMPROVED BIOMASS STOVES

While improved biomass cookstoves could be offered as options to expand clean cooking practices in Rwanda, low affordability and a lack of awareness pose barriers to adoption. In the survey, households currently using three-stone/open-fire stoves or traditional biomass stoves were asked whether they were willing to pay for an improved firewood cookstove with higher fuel efficiency and less emissions at different price points. As shown in figure 62, 83.8 percent of these households were willing to pay for an improved firewood cookstove at RWF 2,500 (~US$2.4), in full or in installments. Additionally, 73.6 percent of the households showed a willingness to purchase a firewood stove at RWF 7,500 (~US$7.3).

For households not willing to accept the offer of an improved cookstove, affordability is the challenge. More than three-fourths of such households reported their inability to afford such a cookstove (figure 63); 16 percent said they were not willing to accept an improved stove because they did not need one. To increase clean cooking practices in Rwanda, it would be crucial to relieve the cost burden due to the transition to improved cookstoves and launch campaigns to raise awareness of clean cooking practices.

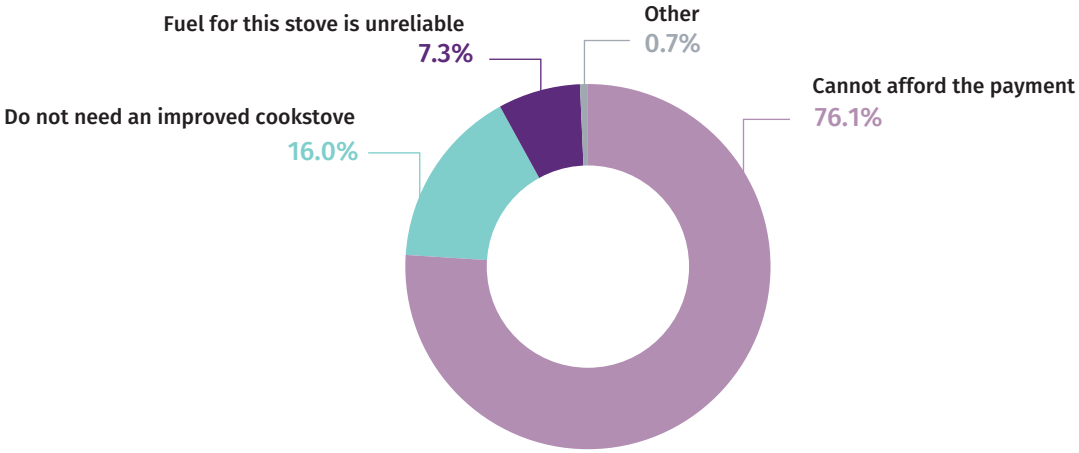
FIGURE 62 • Willingness to pay for an improved firewood cookstove (nationwide)



Source: World Bank 2022.

Note: RWF = Rwandan franc.

FIGURE 63 • Why households are not willing to pay for an improved stove (nationwide)



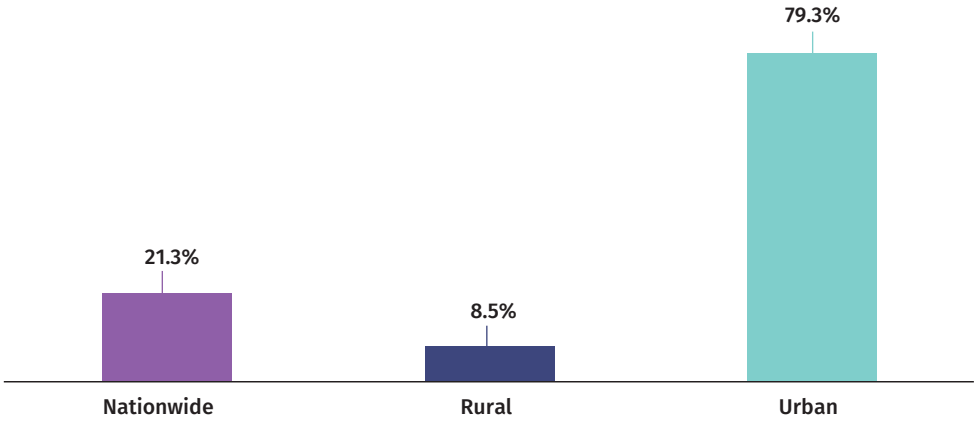
Source: World Bank 2022.

LPG STOVES AS A CLEAN COOKING OPTION, WITH HIGH FUEL COST AS A BARRIER

While LPG cookstoves could be a clean cooking option for Rwandan households, especially in urban areas where the availability of LPG is high, high fuel costs would pose a barrier. In this analysis, a village was assumed to have access to LPG stoves when at least 1 of the 18 surveyed households used LPG stoves. Based on this assumption, the survey shows a high share, 79.3 percent, of LPG stove access in urban areas, compared with an 8.5 percent share in rural villages (figure 64). While 31.4 percent of urban households with stove availability use LPG stoves as their primary cookstoves, 11 percent of rural households with access to LPG stoves use them (figure 65). To increase clean cooking practices among households, promoting the use of LPG stoves could be effective, especially in urban areas, where the LPG adoption rate is higher.

However, fuel cost would hinder the expansion of LPG stoves. As mentioned earlier, under stove stacking, all households owning LPG stoves but keeping them aside reported high fuel prices. To expand the use of LPG stoves, it will be crucial to provide the financial means to relieve the cost burden posed by fuel.

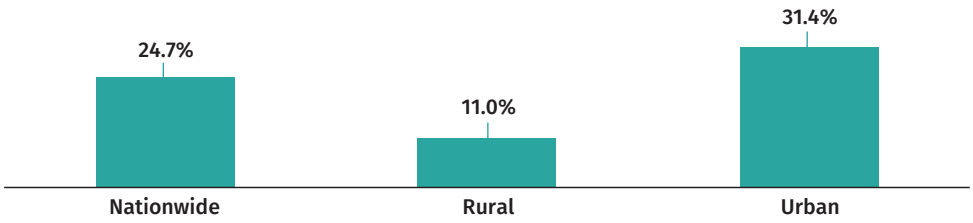
FIGURE 64 • Share of villages with LPG availability



Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

FIGURE 65 • LPG stove adoption of households in villages where LPG is available, by locality



Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

3.3 POLICY RECOMMENDATIONS

LAUNCH AWARENESS CAMPAIGNS TO ENCOURAGE CLEAN COOKING PRACTICES

The measurement of access to clean cooking based on the MTF reveals a threat from unhealthy cooking practices to most Rwandan households, of which 92 percent are Tiers 0 and 1 for their final Cooking Tier classification. There is a need to promote campaigns to advertise and educate on clean cooking practices, their health impacts, and their cost-effectiveness, besides stimulating demand for improved cookstoves. Since the use of clean cooking methods is negligible outside the City of Kigali, promoting campaigns in the lagging regions as well as the City of Kigali will be crucial.

ACCELERATE CLEAN FUEL ADOPTION IN URBAN AREAS

Following the increase in LPG stoves' penetration in urban areas from 2016 to 2022, the Government of Rwanda should accelerate this transition and implement policies and launch campaigns to encourage urban households to switch from traditional biomass stoves to cleaner alternatives, such as electric stoves and LPG stoves.

LOWER THE COST BURDEN OF FUELS FOR IMPROVED COOKSTOVES

The survey shows that all households keeping aside LPG stoves and 99.6 percent of households stacking manufactured biomass stoves do not use them most of the time because of the high fuel cost; instead, they use less clean stoves, which heighten their exposure to health threats. To reduce the cost burden from fuels and promote clean cooking practices among households, factors driving up fuel costs should be identified and measures to relieve the cost burden should be studied and implemented.

PROMOTE RESEARCH AND DEVELOPMENT ON EFFICIENT AND AFFORDABLE CLEAN COOKING SOLUTIONS

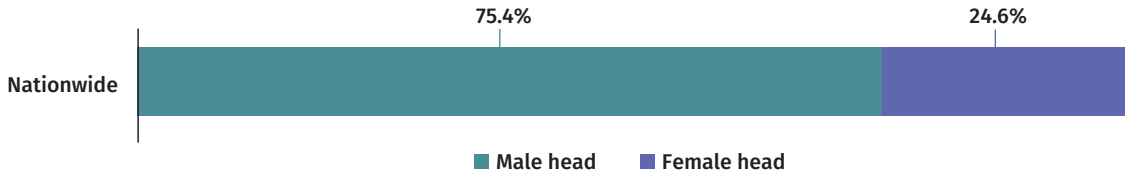
The survey shows that nationwide, the highest share, 67.2 percent, of Rwandan households still cooked with three-stone/open-fire stoves or traditional/locally built stoves in 2022. LPG stoves could barely be an option for some households to switch to a better-performing stove, since their availability is mainly limited to urban areas, and the fuel cost is high. Instead, affordable, efficient cooking options should be available to households. There is a need to initiate research and development of affordable clean cooking solutions in collaboration with local experts and manufacturers.

4. GENDER ANALYSIS

4.1 RWANDA GENDER OVERVIEW

In Rwanda, male household heads are more common than female heads. As shown in figure 66, 75.4 percent of households are male headed, and 24.6 percent are female headed.[14] The ratio does not differ substantially across the rural-urban divide; 27.2 percent of urban households are female headed, versus 24.1 percent of rural households.

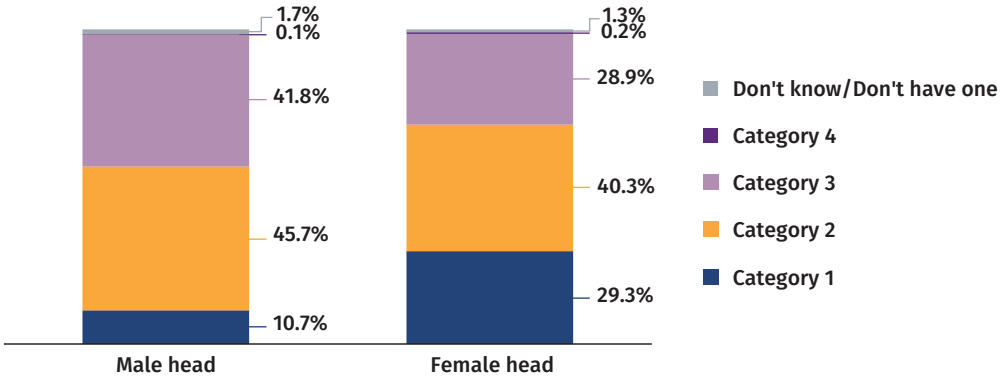
FIGURE 66 • Nationwide distribution of households, by sex of household head



Source: World Bank 2022.

More female-headed households are socioeconomically vulnerable than male-headed households. Three times as many female-headed households as male-headed households are in Ubudehe Category 1 (figure 67).

FIGURE 67 • Household distribution based on Ubudehe category, by sex of household head

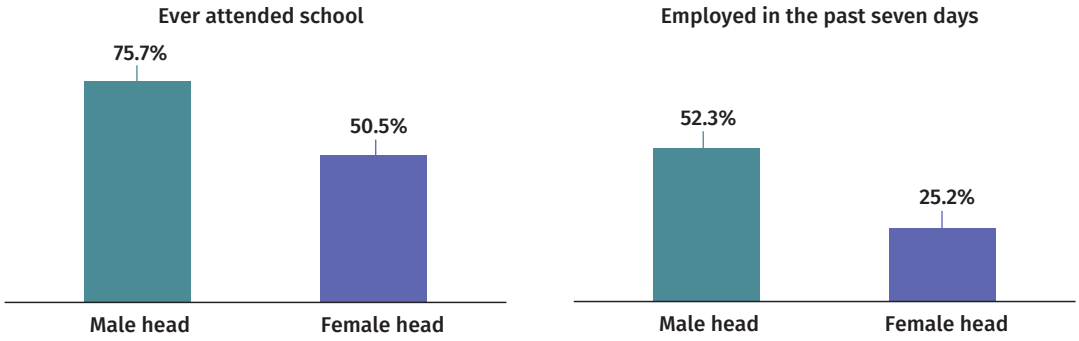


Source: World Bank 2022.

[14] The 5th Rwanda Population and Housing Census in 2022 showed that nationwide, 28.9 percent of Rwandan households were female headed. By locality, 26.4 percent and 29.9 percent of urban and rural households, respectively, were female headed (NISR 2023).

Male household heads are more likely to be educated and employed than female heads. While 75.7 percent of male households attended school, the share is lower by 25.2 percentage points among female heads (figure 68). Also, more than half of male heads were employed in the seven days preceding the survey, whereas the employment rate among female heads was 27.1 percentage points lower.[15]

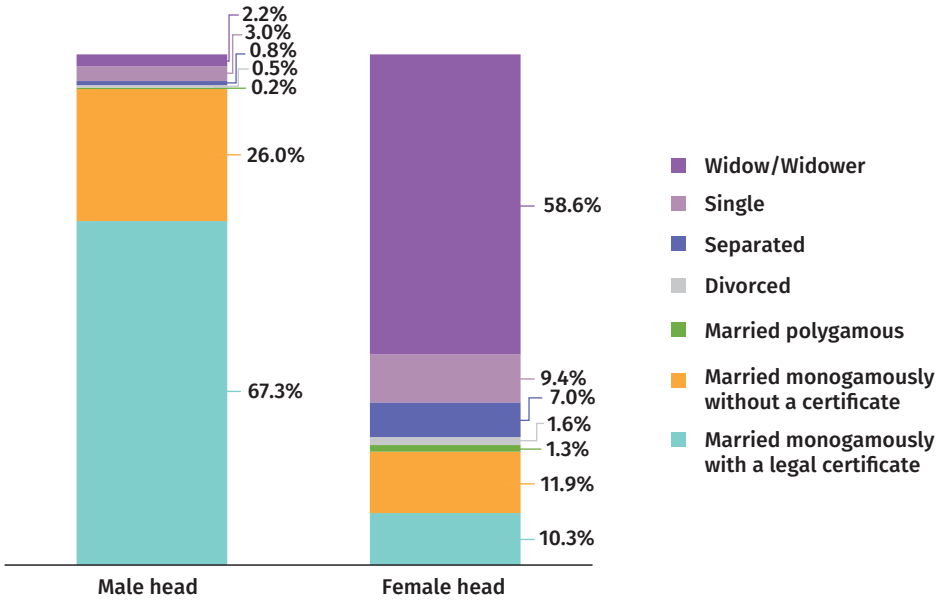
FIGURE 68 • Education and employment of household head, by sex



Source: World Bank 2022.

Male heads are more likely to be married than female heads. Among male heads, 93.3 percent were married, with or without a legal certificate, whereas just 22.2 percent of female heads were married (figure 69). Women tend to head households when they do not have a spouse. Among female heads, 58.6 percent were widows, 9.4 percent were single, and 7 percent were separated, while a smaller share of male heads had the separated marital status.

FIGURE 69 • Marital status of household head, by sex



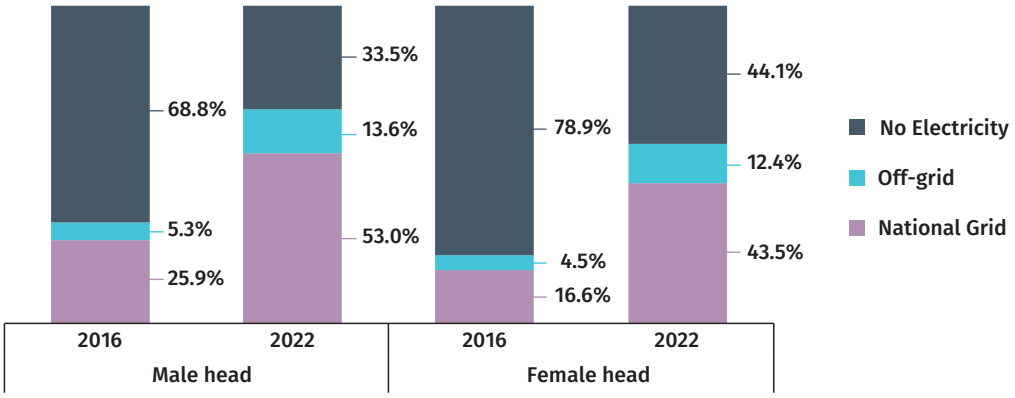
Source: World Bank 2022.

[15] Employed status includes doing any work for pay, doing any kind of business, farming, or other activities to generate income, even if only for one hour.

4.2 ELECTRICITY ACCESS

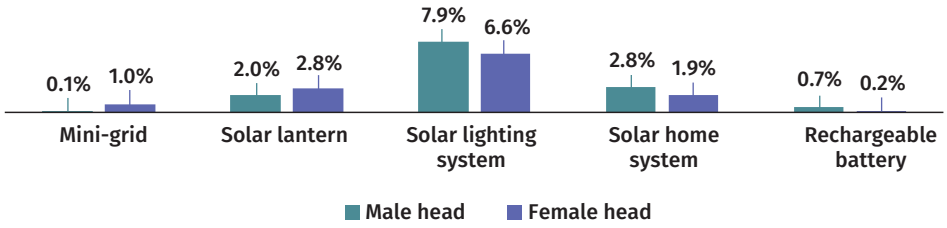
While electricity access among female- and male-headed households showed similar improvements over 2016–2022, access was lower among female-headed households. Among female-headed households, 55.9 percent had access to at least one electricity source, about 11 percentage points lower than the share of male-headed households with access (figure 70). The difference is mainly due to the households' grid rate. Among female-headed households, 43.5 percent rely on the national grid as their primary source of electricity, whereas the rate is higher, by about 10 percentage points, among male-headed households. Access to off-grid solutions does not differ much between the two groups, and for both, solar lighting systems are the commonly used off-grid technology (figure 71).

FIGURE 70 • Access to electricity-providing technologies, by sex of household head



Source: World Bank 2022.

FIGURE 71 • Access to electricity technologies, by sex of household head



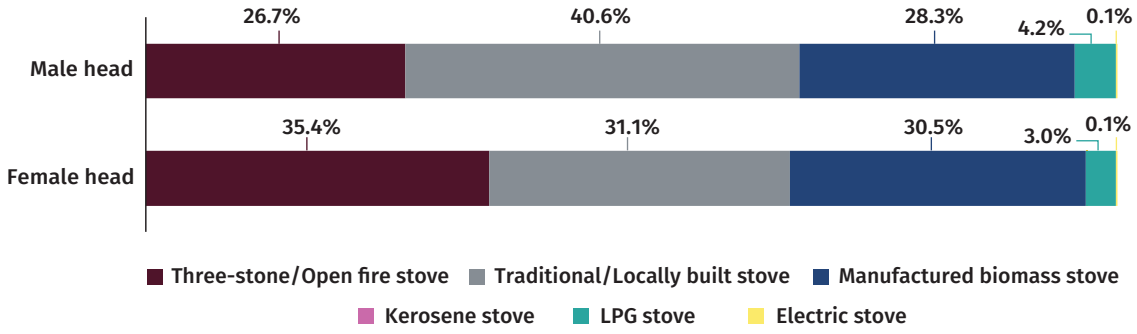
Source: World Bank 2022.

4.3 ACCESS TO MODERN ENERGY COOKING SERVICES

The use of clean cookstoves by sex of household head does not differ significantly among households. The difference in the share of male- and female-headed households using liquefied petroleum gas (LPG) stoves and electric stoves is only negligible (figure 72). Both male- and female-headed households rely heavily on three-stone/open-fire stoves and traditional biomass stoves.

Male-headed households are more likely to adopt LPG stoves than female-headed households. In villages where LPG stoves are available, 27.3 percent of male-headed households use LPG stoves nationwide, whereas the proportion is 9.4 percentage points lower among female-headed households (figure 73).

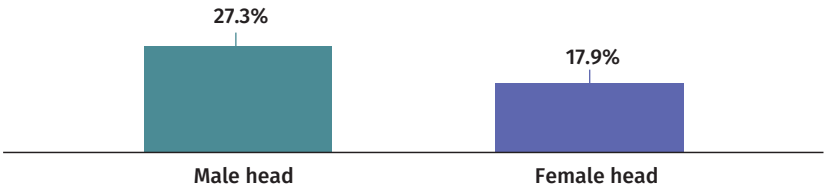
FIGURE 72 • Primary cookstove, by sex of household head



Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

FIGURE 73 • LPG stove adoption, by sex of household head



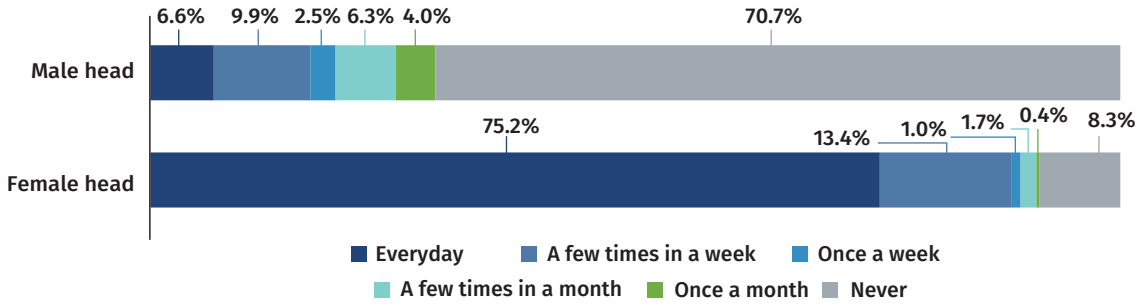
Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

In Rwanda, female household heads cook more often for their families than male heads. As shown in figure 74, 75.2 percent and 6.6 percent of female and male heads, respectively, cook every day for their households, and 70.7 percent of male heads reported never cooking.

In accordance with the findings outlined above, female household members spend more time on cooking and preparing for it than male members. On a typical day, female members spend on average 86 minutes on preparing the fuel and stove along with cooking, whereas male members spend only 17 minutes. The greater presence of female household members in cooking activities suggests that improvements in the cooking environment will benefit them most.

FIGURE 74 • Frequency of cooking, by sex of household head



Source: World Bank 2022.

4.4 POLICY RECOMMENDATIONS

Gender-targeted financing mechanisms are required to increase off-grid solar solutions for female-headed households.

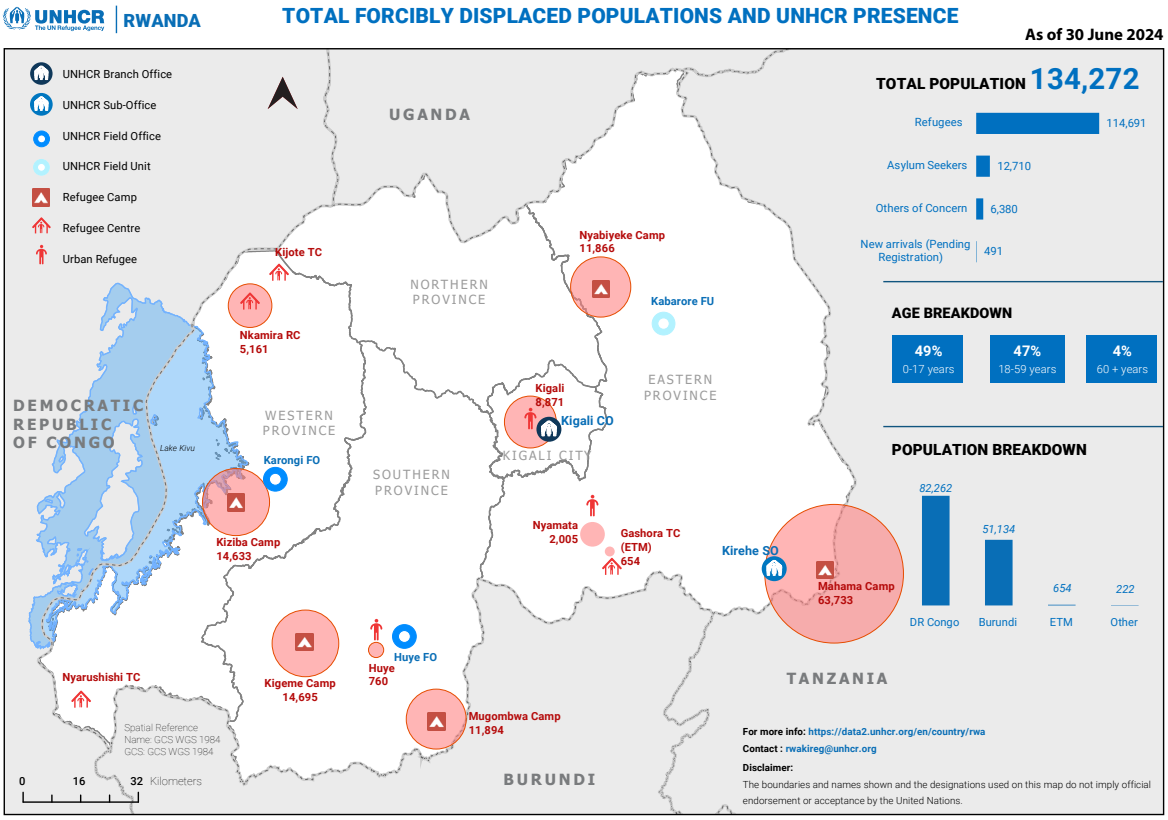
Gender-targeted subsidies for improved cookstoves could significantly improve access to such stoves. Female household members spend more time collecting and preparing cooking fuel and spend more time in the cooking space. They would thus benefit the most from switching to improved cookstoves. Cookstove-related promotion campaigns and dissemination efforts should be adequately tailored to both a male and female audience, taking into account the contextual situations of urban and rural settings.

5. REFUGEE HOUSEHOLD ANALYSIS

5.1 BACKGROUND

Rwanda has been hosting refugees for over two decades since the arrival of Congolese refugees after civil war broke out in the Democratic Republic of Congo in 1996 (UNHCR 2021). Today, Rwanda continues providing refugee protection in coordination with the United Nations High Commissioner for Refugees (UNHCR) (MINEMA, n.d.); as of the end of June 2024, 134,272 refugees and asylum seekers, predominantly from the Democratic Republic of Congo and Burundi, were registered in the five refugee settlements of Rwanda: the Kigeme, Kiziba, Mahama, Mugombwa, and Nyabiheke camps (map 2).

MAP 2 • Refugee settlements of Rwanda



Source: UNHCR 2024.

REFUGEE INTEGRATION POLICIES IN RWANDA

The Government of Rwanda (GoR) has actively implemented policies for refugees' protection and their inclusion in Rwanda's society. In 2016, it announced four commitments for the inclusion of refugees in the national system at the Leader's Summit for Refugees in New York: helping camp-based refugees graduate from assistance programs and increasing formal access to employment opportunities, providing all refugees with ID cards, integrating refugee children into national education systems, and granting urban refugees access to national health insurance systems (MINEMA, n.d.). In 2018, the GoR signed on to adopt the Comprehensive Refugee Response Framework, which provides for a more comprehensive, predictable, and sustainable response that benefits both refugees and the host community (UNHCR 2018). To ensure an improved standard of living for refugees and host communities, in February 2019, the GoR established the Strategic Plan for the Inclusion of Refugees (2019–24), which assesses the baseline status for achieving the four commitments from 2016; identifies challenges and strategic objectives; and establishes prioritized activities, a financial strategy, and a monitoring framework (Global Compact on Refugees, n.d.b).

During the Global Refugee Forum, the four commitments were renewed, and the topic of refugee integration was extended to the environment and energy. The GoR pledged to "undertake environmental protection and rehabilitation in refugee hosting areas" and "ensure sustainable use of natural resources by providing clean and renewable energy solutions in refugee and host community households" (UNHCR 2020; MINEMA 2022). In 2021, Rwanda's Ministry in charge of Emergency Management (MINEMA) developed the Economic Inclusion Strategy (2021–24) jointly with the UNHCR. The strategy aims at helping refugees graduate and move out of poverty (UNHCR, n.d.). Today, MINEMA works closely with government branches and the UNHCR toward fulfilling the commitments and objectives (Global Compact on Refugees, n.d.b).

ENERGY ACCESS IN REFUGEE CAMPS

Access to electricity and clean cooking has been promoted for refugee households in recent years. The UNHCR has installed solar streetlights in refugee locations since 2017 (UNHCR 2022), and the development of a solar market system[16] under the Renewable Energy for Refugees (RE4R) project led by Practical Action, a global charity, and UNHCR from April 2017 to February 2022 increased households' access to solar home systems (SHSs)[17] in the Gihembe,[18] Kigeme, and Nyabiheke camps (Practical Action, n.d.).

Access to clean cooking among refugee households has grown due to the distribution of liquefied petroleum gas (LPG) cylinders, fillings, and cookers by the UNHCR to households in the largest refugee camps of Mahama and Mugombwa, in response to the GoR's ban on firewood in refugee camps in 2018 (UNHCR 2022). Also, many refugee and host community households transitioned to an improved cooking solution during 2019–21 with the UNHCR's support (UNHCR 2022). The survey shows that, as of mid-2022, 38.3 percent of refugee households across the five camps had at least one source of electricity, and 62.1 percent of refugee households had access to cooking with LPG.

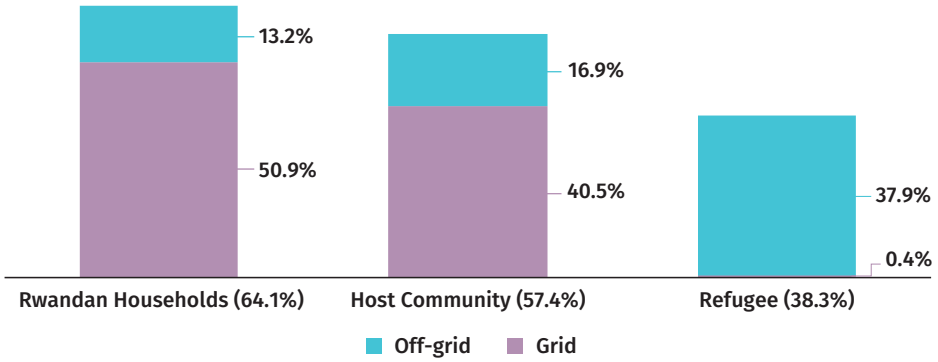
[16] The market-based approach included assisting private sector companies to adapt business models for refugee markets and global advocacy, strengthening and supporting markets, and promoting economic activity for refugees and host communities (Practical Action, n.d.).
[17] Note that the definition of an SHS in the RE4R project is based on the system's components (Practical Action 2021). That is different from how an SHS is defined in this report, based on the service level (box 1).
[18] Refugees in the Gihembe camp were relocated to the Mahama camp by December 2021 due to the environmental hazards caused by eroded ravaging ravines and old infrastructures (MINEMA 2021).

5.2 ACCESS TO ELECTRICITY

ELECTRICITY ACCESS BY TECHNOLOGY

Across all refugee settlements, 38.3 percent of households had access to at least one electricity source—19.1 percentage points less access compared with host community households (figure 75). Only host communities, not refugee households, can access the grid, even though host communities surround refugee settlements at a close distance. Among host community households, 40.5 percent rely on electricity mainly from the national grid, whereas almost no refugee household has grid access and predominantly relies on off-grid technologies, more specifically, solar lanterns and other solar lighting systems (SLSs) (figure 76).

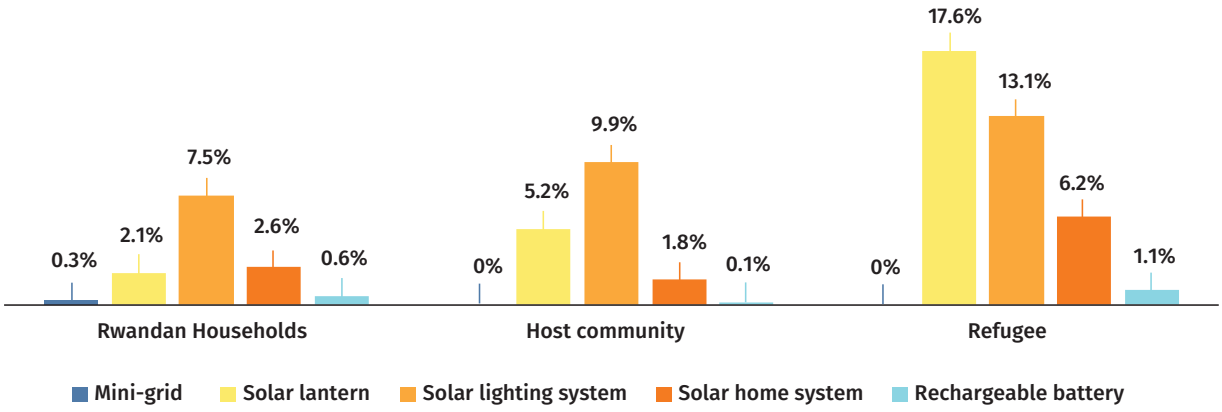
FIGURE 75 • Electricity access among refugee households



Source: World Bank 2022.

Note: The household types were mutually exclusive.

FIGURE 76 • Distribution of off-grid technologies, by type of household

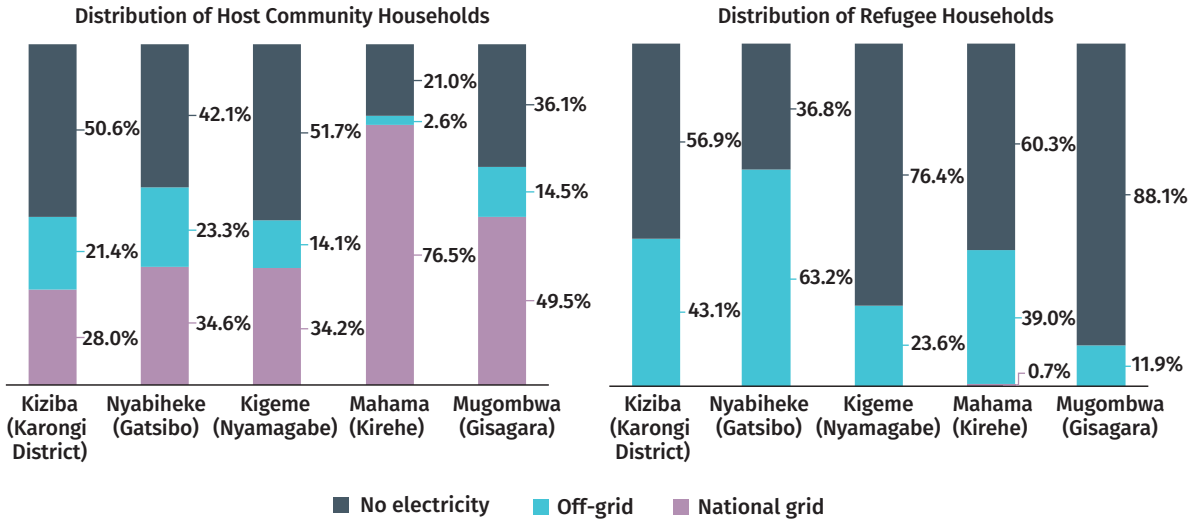


Source: World Bank 2022.

Note: The household types were mutually exclusive.

Across camps, electricity access is especially low in Mugombwa and Kigeme (figure 77). In all camps except Kiziba and Nyabiheke, a major access gap exists relative to host communities. This gap is mainly because grid access is available only to host communities. The use of SLSs is the highest in Nyabiheke, and the use of solar lanterns is the highest in Mahama (figure 78).

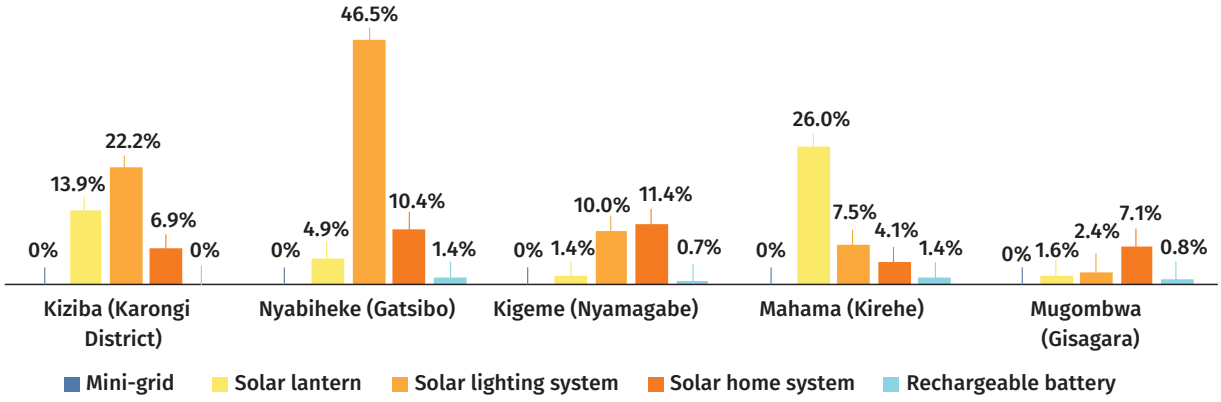
FIGURE 77 • Electricity access among host communities and refugee settlements, by refugee camp



Source: World Bank 2022.

Note: The names of districts are in parentheses following the names of the refugee camps. The graphs are arranged by the year of the camps' establishment in ascending order: from Kiziba, the oldest, to Mugombwa, the newest.

FIGURE 78 • Use of off-grid technologies, by refugee camp



Source: World Bank 2022.

Note: Names of districts of refugee camps in parentheses. Graphs ordered by the year of the camp establishment in ascending order: from Kiziba,

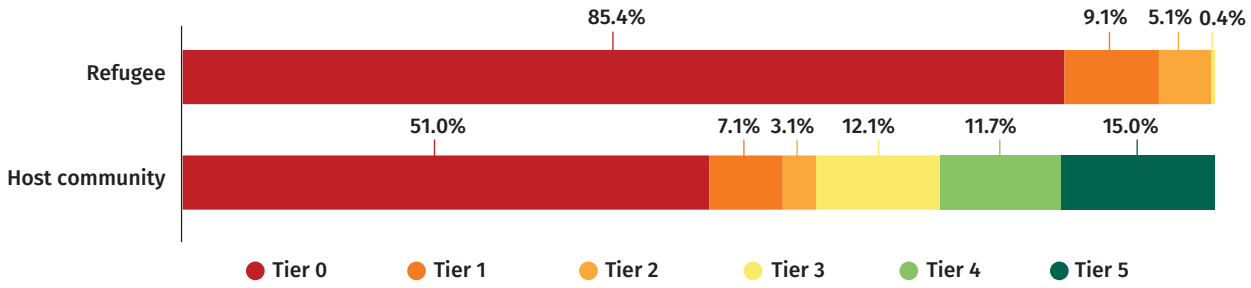
the oldest, to Mugombwa, the newest.

EVALUATING ELECTRICITY ACCESS USING THE MULTI-TIER FRAMEWORK

An assessment using the Multi-Tier Framework (MTF) also confirms that most refugee households do not have electricity access. Although 38.3 percent of refugee households have at least one electricity source (figure 75), only about 15 percent across all camps have an electricity service level that can be considered as having access, falling in aggregate Tier 1 or above (figure 79). The remaining refugee households are Tier 0, because they do not have an electricity source at all, or barely have electricity, which is of substandard capacity and/or whose availability is low. Among the refugee population, 23.7 percent is at Tier 0 despite being connected to a solar technology (figure 80).

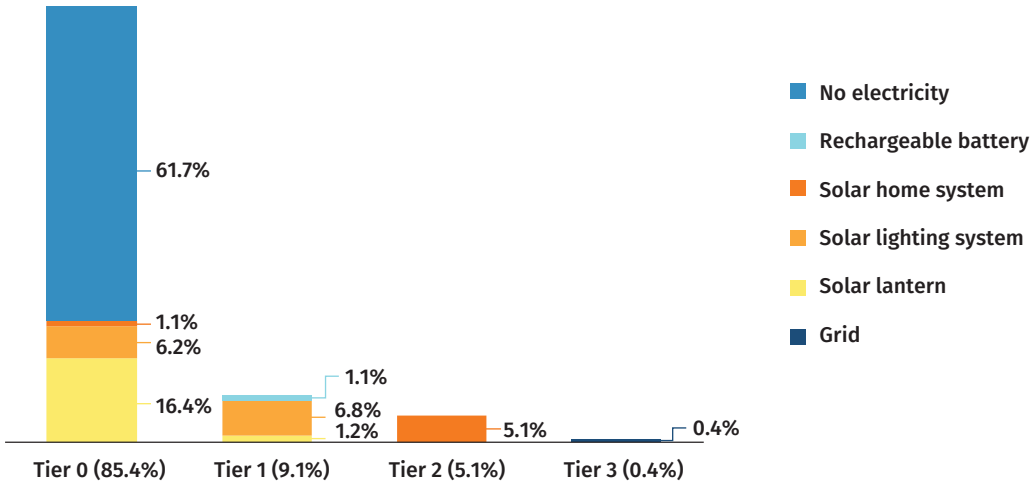
The analysis using the MTF again highlights the clear access disparity between refugee settlements and host communities despite their proximity. Compared with refugee settlements, the share of Tier 1 or higher households is larger among host communities, by 34.4 percentage points (figure 79). Also, while Tiers 3 and 5 households do not exist in the refugee camps, almost 40 percent of host community households are in this tier range due to their connections to the national grid (figure 79; World Bank 2022). These findings suggest that electricity access should be improved in the refugee camps, and based on their proximity to host communities, connecting the national grid could be an alternative worth considering.

FIGURE 79 • Distribution of refugee and host community households based on aggregate Electricity Tier



Source: World Bank 2022.

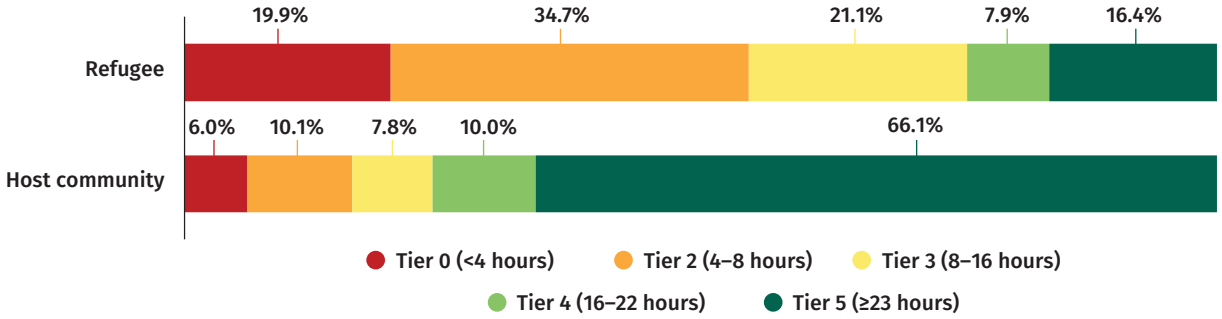
FIGURE 80 • Electricity technology of refugee households in each aggregate Electricity Tier



Source: World Bank 2022.

More than half of refugee households with at least one electricity source receive less than eight hours of electricity per day (figure 81). About 20 percent of households receive less than 4 hours of electricity in an entire day. On the other hand, more than two-thirds of host community households with electricity sources receive electricity 23 hours or more per day. The survey shows that 93 percent of these households adopt the national grid as their primary electricity source (World Bank 2022).

FIGURE 81 • Distribution of refugee and host community households across the all-day Availability Tier

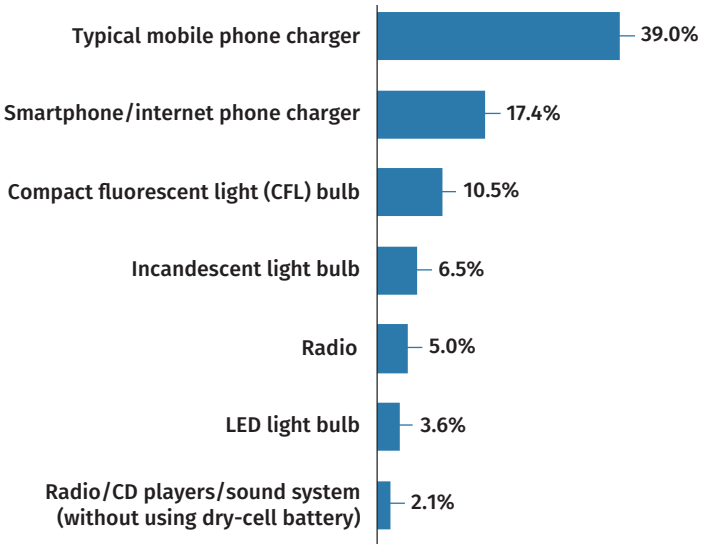


Source: World Bank 2022.

USE OF ELECTRICAL APPLIANCES

Refugee households use primarily low-load electrical appliances. Phone chargers are the most common, and a small number of refugee households use light bulbs and radios (figure 82).

FIGURE 82 • Appliance use among refugee households



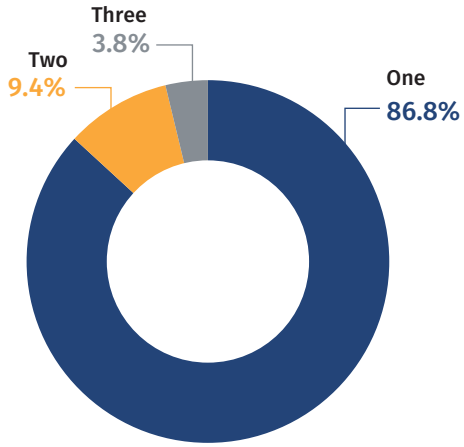
Source: World Bank 2022.

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

USE OF OFF-GRID SOLAR TECHNOLOGIES

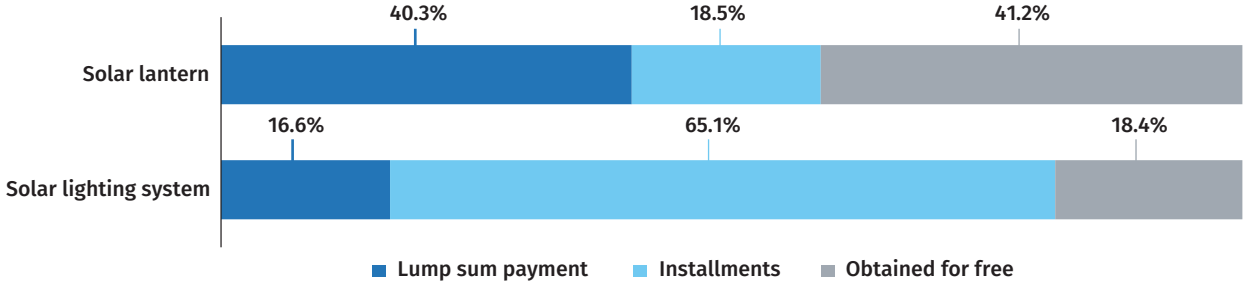
Most refugee households rely on just one solar device for electricity (figure 83). The survey shows that many refugee households using solar lanterns obtained their devices for free, and among the households that paid for their lanterns, a large share made a lump-sum payment up front (figure 84). Of the refugee households using SLSs, the largest share paid for their solar devices in installments.

FIGURE 83 • Number of solar devices



Source: World Bank 2022.

FIGURE 84 • Up-front payment for the main solar device, by technology

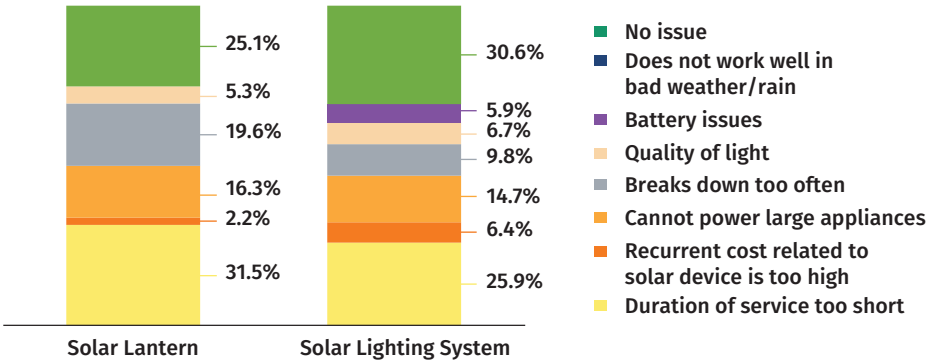


Source: World Bank 2022.

Note: Due to the small sample size, households using solar home systems were excluded in this analysis.

Refugee households using solar lanterns and SLSs reported the short duration of service and the inability to power large appliances, respectively, as the most serious issues with their main solar devices (figure 85). About 20 percent of the refugee households using solar lanterns reported that their solar devices broke down too often. The same issue was reported by almost 10 percent of the households using SLSs, and roughly 6 percent found battery issues to be the most serious concern.

FIGURE 85 • Most serious issues with the main solar device, by technology



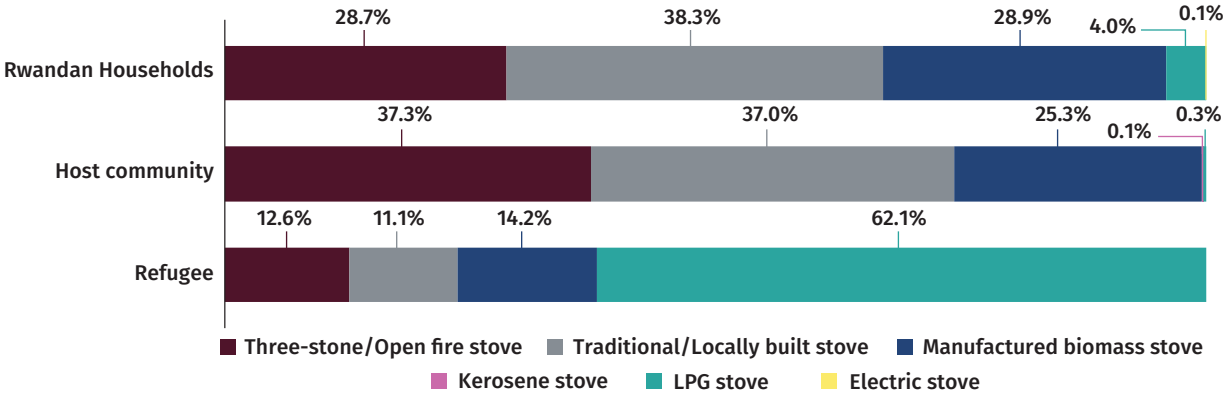
Source: World Bank 2022.

Note: Due to the small sample size, households using SHSs are excluded from this analysis.

5.3 ACCESS TO CLEAN COOKING

Clean stoves are widely used among refugee settlements. Among refugee households, 62.1 percent use LPG stoves, which is significantly higher than the negligible clean stove adoption in host communities (figure 86). However, the high use of LPG cookers appears to be limited to the refugee camps with the UNHCR's intervention. As shown in figure 87, the use of LPG stoves is prevalent in the Mahama and Mugombwa camps, where the UNHCR distributed not only LPG cookers but also their cylinders and fillings, respectively, over 2019–21 (Global Compact on Refugees, n.d.a; Karinganire 2023). On the other hand, households in any other settlements without interventions do not adopt LPG stoves and instead rely on biomass stoves.

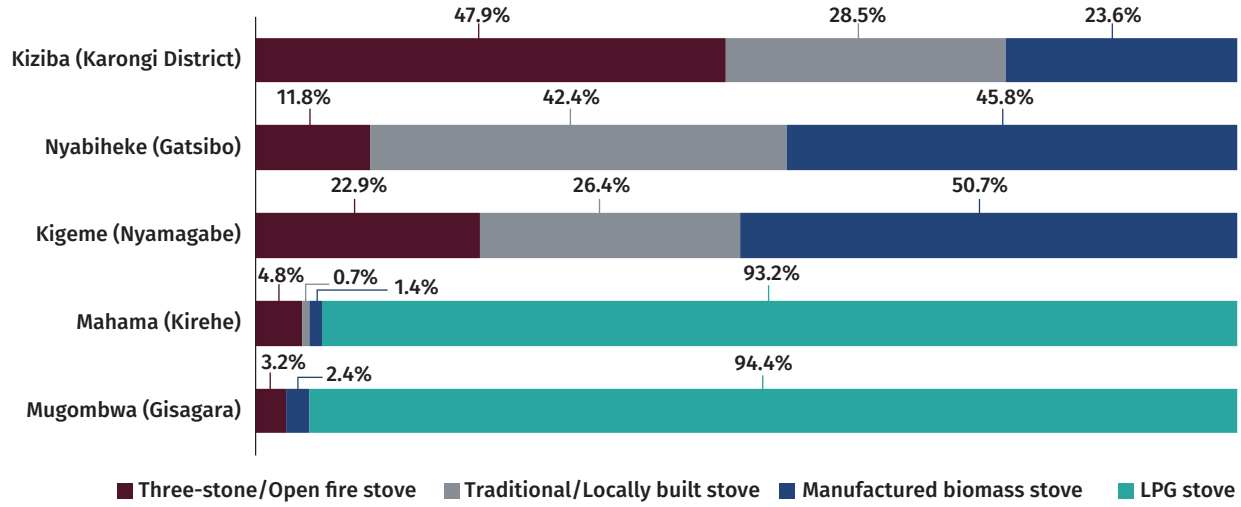
FIGURE 86 • Primary cookstoves of refugee households



Source: World Bank 2022.

Note: The household types were mutually exclusive. LPG = liquefied petroleum gas.

FIGURE 87 • Primary cookstoves of refugee households, by camp

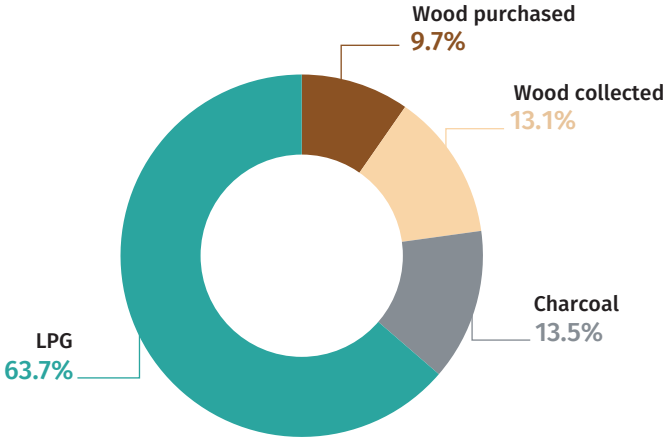


Source: World Bank 2022.

Note: Names of the districts of the refugee camps in parentheses. Graphs arranged by the year of the camps' establishment in ascending order: from Kiziba, the oldest, to Mugombwa, the newest. LPG = liquefied petroleum gas.

In line with the prevalence of LPG stoves, LPG is the most commonly used cooking fuel across all refugee camps (figure 88). More than one in five refugee households still rely on firewood as their cooking fuel. All types of biomass stoves commonly use wood for fuel, and some refugee households use charcoal for their traditional/locally built stoves and manufactured stoves (figure 89).

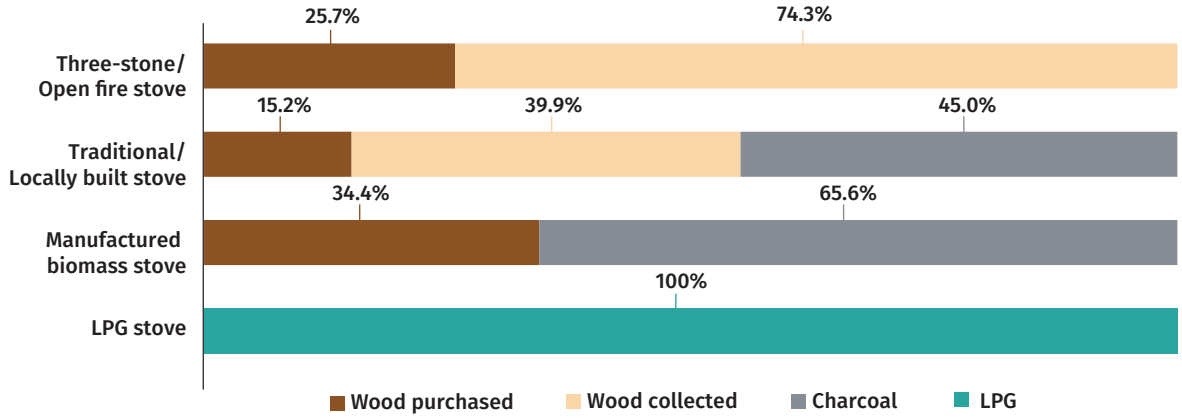
FIGURE 88 • Cooking fuel use among refugee households



Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

FIGURE 89 • Cooking fuel among refugee households, by stove



Source: World Bank 2022.

Note: LPG = liquefied petroleum gas.

5.4 POLICY RECOMMENDATIONS

EXPAND ELECTRICITY ACCESS IN REFUGEE SETTLEMENTS

As the survey shows, 38.3 percent of refugee households had access to electricity sources, but only about 15 percent of them were at Tier 1 or higher. Across all settlements, electricity access should be improved.

Even though refugee camps are in close proximity to host communities, only host communities have grid access. The national grid could be expanded with donor financing support to provide refugee households with higher-tier electricity.

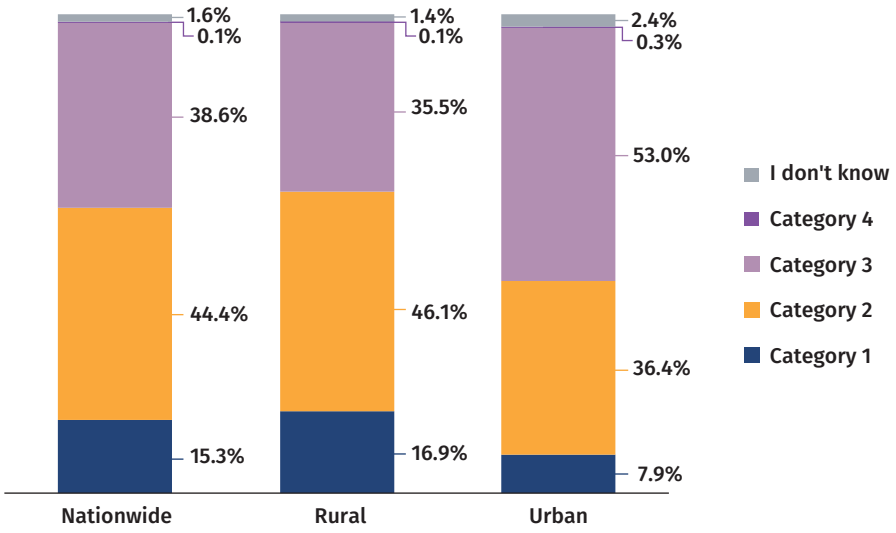
Penetration of off-grid solar technologies can be further increased in refugee camps. The survey shows that off-grid solar technologies are already the most widespread sources of electricity in the refugee settlements, and refugee households are willing to purchase their solar devices. Private sector participation could be facilitated in the refugee settlements, and off-grid solar electrification could be driven leveraging result-based financing.

LAUNCH AWARENESS CAMPAIGNS AND EXPAND OPTIONS FOR CLEAN COOKING

While the refugee camps with the UNHCR's intervention have access to LPG stoves, refugee households in the other settlements often rely on high-emission biomass stoves. Campaigns targeting these households could be launched to promote awareness of clean cooking practices and their benefits. Access to affordable and fuel-efficient cookstoves must be expanded.

ANNEX 1

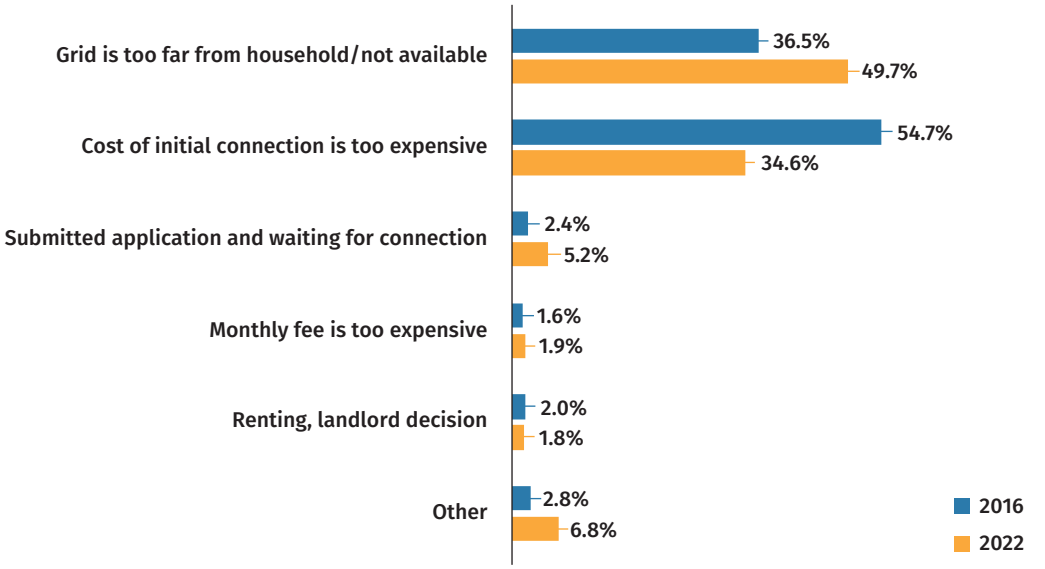
FIGURE A1.1 • Household distribution of Ubudehe category, by locality



Source: World Bank 2022.

ANNEX 2

FIGURE A2.1 • Barriers to household grid connections (2016 vs 2022)



Source: World Bank 2022.

Note: Respondents relied on off-grid electricity sources or were unelectrified

ANNEX 3

TABLE A3.1 • MTF Electricity Tier matrix for the analysis of the Rwanda's public institution survey

ATTRIBUTE		TIER SCORE					
		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Capacity	Appliance Capacity (W)	-	≥3 and <50	≥50 and <200	≥200 and <800	≥800	-
	Main Electricity Source	-	Off-grid solar, generator	Off-grid solar, generator	Off-grid solar, generator	Off-grid solar, generator	National Grid or mini grids
Availability		<2 hrs	Min. 2 hrs	Min. 4 hrs	Min. 50% of working hours	Min. 75% of working hours	Min. 95% of working hours
Reliability *(Disruptions per week)*		-			Disruptions > 14	(4–14 disruptions) OR (Disruptions ≤3 and duration ≥2 hrs)	(Disruptions ≤ 3) AND (Duration < 2 hrs)
Quality		-			With voltage issues	-	No voltage issues
Formality		-			Informal		Formal
Safety		-			Had accidents in the past	-	Safe, no accidents

Source: Bhatia and Angelou 2015.

Note: Tier score range is different for each attribute. A gray cell or block refers to a tier or tiers that do not need to contribute to the relevant score range. For example, a binary/bipolar situation will require only two tiers, and hence, the apparently discontinuous or partial sequences of tiers illustrated. hr = hour.

ANNEX 4

TABLE A4.1 • Electricity end-user tariffs for residential customers in Rwanda

Customer Category	Tariff
Low voltage—all (residential and nonresidential)	182

Consumption Block (kWh per Month)	Tariff (VAT and regulatory fee exclusive) (RWF/kWh)
<15	89
15–50	212
>50	249

Sources: RURA 2015, 2020.

Note: kWh = kilowatt hour; RWF = Rwandan franc; VAT = value-added tax.

ANNEX 5

TABLE A5.1 • Solar products considered in the willingness-to-pay survey module

Tier	Product	Price (RWF)	Subsidy Level (%)	Subsidy Amount (RWF)	Current Maximum Subsidy Amount (RWF)	WTP Price Points (RWF)
Tier 1	- **Company:** Lemi - **Model:** LM-LI020 - **Specifications:** With 3 lamps, a mobile phone charger, 36-month warranty 	150,000	90	135,000	100,000	15,000
			70	105,000	80,000	45,000
			45	67,500	50,000	82,500
Tier 2	- **Company:** Bbox - **Model:** Bpower50 U2 - **Specifications**: With 4 lamps, 1 portable light, a 24'' TV, a radio, 24-month warranty 	350,000	-	135,000	100,000	215,000
			-	105,000	80,000	245,000
			-	67,500	50,000	282,500

Source: Brutinel 2022.

Note: RWF = Rwandan franc; WTP = willingness to pay.

ANNEX 6

TABLE A6.1 • Improved cookstoves considered in the willingness-to-pay survey module

Type of Stove	Product	WTP Price Points (RWF)
Firewood	Songa (easy to operate, fuel efficient, less smoke) 	Two price points: - 2,500 - 7,500
Charcoal	Ecozoom Jiko bora mama yao (easy to operate, fuel efficient, less smoke) 	Two price points: - 16,000 - 21,000
LPG	Realflame Elite (clean, fast) 	Three price points: - 8,200 - 24,600 - 45,100

Source: Brutinel 2022.

Note: RWF = Rwandan franc; WTP = Willingness-to-Pay.

ANNEX 7

TABLE A7.1 • Cookstoves in Rwanda

Three-Stone Stove		
Stove Type	**Photograph**	**Fuel**
Three-stone		Firewood
Traditional/Locally Built Stoves		
Stove Type	**Photograph**	**Fuel**
Round mud stove		Firewood
Gisafuriya stove		Firewood
Rocket stove		Firewood
Double-place metal stove		Charcoal
All metal charcoal stove	 	Charcoal
Manufactured Biomass Stoves		
Stove Type	**Photograph**	**Fuel**
Darfour stove		Firewood
Mimi Moto		Pellets

Claded Canarumwe		Charcoal
Uncladed Canarumwe		Charcoal
Canamake		Charcoal
Installed Canarumwe		Firewood
Ruliba Clay		Charcoal
Save 80		Firewood
Ecozoom		Firewood
Jiko Malkia		Firewood
Mahwi		Charcoal
EcozoomJiko Bora Mama Yao PNG 40		Charcoal
ECOZOOM Dura Rocket stove		Firewood
GreenWay Jumbo		Firewood
Ruliba Clay		Firewood

Gisubizo S26-13		Briquettes—firewood
Ecozoom Jiko Fresh		Charcoal
JIKO Malkia		Charcoal
SONGA stove		Firewood
Gisubizo C28-23 Max		Briquettes—charcoal
AJDR Charcoal stove		Charcoal
Igisubizo		Charcoal waste
ZIGAMA stove		Firewood
Umurabyo		Charcoal

LPG Stove		
Stove Type	**Photograph**	**Fuel**
All–liquefied petroleum gas (LPG) stoves	 	LPG

Electric Stove		
Stove Type	**Photograph**	**Fuel**
All-electric stoves	  	Electricity

Source: CESS Ltd. 2022b.

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