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**RWANDA**

**Beyond Connections**

Energy Access Diagnostic Report Based on the Multi-Tier Framework

**COPY FOR THE DECESION REVIEW**

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# ACKNOWLEDGEMENT [to be updated]

# ABBREVIATIONS

|  |  |
| --- | --- |
| CFL | Compact Fluorescent Lights |
| DRC | Democratic Republic of Congo |
| ESMAP | Energy Sector Management Assistance Program |
| GDP | Gross Domestic Product |
| GoR | Government of Rwanda |
| ICS | Improved Cookstove |
| 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 |
| PNG | Piped Natural Gas |
| REAR | Renewable Energy for Refugees |
| RPHC | Rwanda Population and Housing Census Report |
| RWF | Rwandan Franc |
| SDG | Sustainable Development Goal |
| SHS | Solar Home System |
| SLS | Solar Lighting System |
| W | Watt |
| WTP | Willingness to Pay |
| UNHCR | United Nations High Commissioner for Refugees |
| UPS | Uninterruptible Power Supply |
| USD | United States Dollar |

\* 1 U.S. Dollar = 1,023 Rwandan Franc in June, 2022

# EXECUTIVE SUMMARY

This report presents the findings from the second national energy access survey implemented in Rwanda in June 2022 after the first survey in 2016. The survey captured the status of access to electricity and clean cooking of Rwandan households including refugee households and public institutions. The survey was analyzed using the Multi-Tier Framework (MTF) for Energy Access, which measures the level of energy access instead of assessing it in binary definition, having access or not, and explores the multi-dimensional nature of energy access and the vast range of technologies and sources that can provide energy access. Findings from the MTF analysis based on full-spectrum data can inform energy policy designs in Rwanda, empower data-driven policy making, and help making progress towards the seventh of the 17 United Nations Sustainable Development Goals (SDGs): to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030.

The Multi-Tier Framework measures electricity access in Rwanda with six attributes: electricity capacity, available hours of electricity during the whole day and only in the evening, reliability of connection, voltage quality, formality of connection, and safety. For each of these attributes, households are placed in a tier depending on their level of service, and the lowest tier score households obtain among the six becomes their final tier classification, or the aggregate electricity Tier, ranged from Tier 0 (no access) to Tier 5 (full service). Households classified as Tier 1 or above for their final tier classification have electricity access though its level and quality might need improvements. Households falling into Tier 0 do not have electricity sources at all, or they have electricity but its capacity and/or availability are/is too poor to count as having electricity access.

With the same 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 of the four becomes the final tier classification for a household, or the aggregate cooking Tier, between Tier 0 and 5. Households in aggregate Tier 2 or above for their final tier classification have access to clean cooking services (aggregate Tier 4 and 5) or at least improved cooking services in transition to clean cooking (aggregate Tier 2 and 3). Households falling into Tier 0 and 1 are not considered to have access to clean cooking services since their health and safety are critically threatened by cooking activities.

## Access to Electricity

**Rwanda showed significant improvement in electricity access by mid-2022 with nationwide 63.9% of Rwandan households having access to at least one source of electricity**, which increased from 28.6% in late 2016.

**Rwanda achieved major progress in rural electrification, but disparity in electricity access between rural and urban areas remains large in 2022.** In rural areas, electricity access markedly grew from 17.5% in 2016 to 57.9% in 2022. Despite the achievement, the access rate is 33.7 percentage points lower than 91.6% of urban areas in 2022.

**The national grid is the most prevalent electricity source in Rwanda, especially in urban areas including Kigali City.** Nationwide 50.7% of households rely on the national grid as their main electricity source in 2022. The rate increased more than twice compared to 2016. In rural areas, 42.2% of households use the grid for their primary electricity source in 2022, while in urban areas, the rate is 89.3%. By province, the share of households connected to the grid is 93.8% in Kigali City and 54% in the Eastern province. In all other provinces, less than half of the population is grid-connected.

**Off-grid technologies, especially solar solutions, serve as effective electricity sources for rural households.** In rural areas, 15.7% of households rely on off-grid technologies as their primary electricity source, while in urban areas, a much smaller proportion of 2.4% choose off-grid solutions. The most popular off-grid technology in Rwanda is solar lighting systems other than solar lanterns. In most provinces, at least one household out of ten use off-grid technologies, while in Kigali City, the proportion is negligible.

**Socio-economically more vulnerable households tend to show low electricity access.** Ubudehe Category 1 shows the highest share of households without electricity access and the lowest proportion of households with grid access. When the Ubudehe Category increases, the percentage of households connected to the national grid increases, but the share of households without any electricity sources drops.

**Nationwide, 58.9% of households have electricity access at Tier 1 level or higher based on their final tier classification from the MTF analysis.** The rest of households either do not have access to any electricity sources, or the capacity and/or availability of their electricity are/is too low to count as with-access. In rural areas, about half of households have the with-access level of electricity, while in urban areas, the rate is much higher 90.9%.

**Although access to the national grid substantially grew, the consumption of grid electricity remains low in 2022.** The monthly average grid consumption of Rwandan households is 16.8 kwh, which is lower than the average consumption of nearby East African countries like Kenya with 48.6 kWh and Uganda with 42 kWh. By locality, urban households monthly consume on average 28.6 kWh of electricity, while rural households consume 11.3 kWh. Despite the connection to the national grid, many households do not take advantage of the capacity available from the grid and use mostly low-load devices.

**For households without grid connections, distance from the grid and the cost burden from initial connections are the major challenges.** Cost burden from initial connection is still a barrier despite the grid connection policy from 2017, which allowed applying for a grid connection at no initial cost and repaying the fee from power purchase (Rwanda Energy Group 2017). The share of households that reported the expensive connection cost as a barrier decreased from 54.7% in 2016 to 34.6% in 2022 nationwide. Nevertheless, for many Rwandan households, especially those without any source of electricity, the initial connection cost is a constraint to have the grid connection.

**The majority of grid-connected households do not find problems with their grid electricity, but for some households, electricity reliability is a concern.** Of households with grid connections, 57% face either four to 14 outages per week or experience less than four interruptions lasting longer than two hours.

The common challenges households relying on any off-grid solar solutions for their main electricity source report are limited electricity availability, low capacity, and poor quality of light. **Of households using solar home systems, 16.7% of households report the burden from recurrent costs related to their solar devices as the problem.**

**Public institutions in Rwanda show high electricity access, and they predominantly use the grid as their main electricity source.** All health facilities in Rwanda have electricity access, and 98.5% of them use the grid electricity. Electricity access for education facilities is relatively lower, 86.3%. Among the schools with access to electricity sources, 85.6% rely on the national grid, while the rest use off-grid solar technologies.

## Access to Modern Energy Cooking Services

**Clean cooking practices are rare in Rwanda as of 2022 with only about 4% of households nationwide cooking with clean stoves like LPG stoves and electric stoves.** 67.2% of Rwandan households still use three-stones open fire stoves and traditional/locally built stoves mostly burning firewood.

**Clean stoves are adopted mostly in urban areas; by province, Kigali City shows the highest use of clean stoves.** In 2022, 19% of urban households use LPG stoves for cooking, which sharply increased from 1.7% in 2016. However, in rural areas, only 0.6% of households adopt LPG stoves. By province, more than one fifth of households in Kigali City cook with LPG stoves, but in all other provinces, the stove use is negligible.

**Households in higher Ubudehe Categories tend to use cleaner stoves.** Households in Category 3 shows the highest use of LPG stoves and manufactured biomass stoves, while the share decreases for lower Categories.

**In Rwanda, wood is the most predominant cooking fuel, especially in rural areas.** In rural areas, almost 90% of households use wood for their cookstoves, while in urban areas, the share is about 20%. In urban areas, charcoal is the most prevalent fuel used by 73.5% of urban households.

The MTF analysis shows that **in 2022, nationwide only about 4% of households have access to clean cooking, and** **92% of households fall into Tier 0 and 1 as their final cooking tier classification, which suggests that many Rwandan households are still exposed to threats from unhealthy cooking practices**. In rural areas, 97% of households lie between Tier 0 and 1, while the proportion is 69% in urban areas. Although urban areas have better access to clean cooking with a higher proportion of households in Tier 5 (19%) compared to rural areas (0.6%), overall clean cooking access is low in both localities.

**Improved firewood cookstoves and LPG stoves could be options to expand clean cooking practices; however, households’ low affordability could hamper the transition.** Many Rwandan households currently using either three-stones/open fire stoves or traditional biomass are willing to pay for an improved firewood cookstove either at lump sum or installments especially when the stove is cheaper. However, households never willing to pay for the improved stoves report affordability as the barrier for the transition. LPG stoves can be suggested as a clean cooking option to households in urban areas where availability of LPG stoves is high, but the expensive fuel cost will be the challenge.

## Gender Analysis

**In Rwanda, male-headed households are predominant.** Nationwide 75.4% of households are led by male heads, while only about a quarter of households are female-headed. The gender ratio is similar across rural and urban areas. A higher share of female-headed households falls into Ubudehe Category 1 compared to male-headed households, which shows that female-headed households are poorer. Male heads are more likely to be educated and employed compared to female heads.

A gender gap exists in access to electricity and modern energy cooking solutions. **Female-headed households are slightly lower in their electricity access by about 10 percentage points compared to male-headed households.** Male-headed households show a higher grid adoption rate by about 10 percentage points compared to female-headed households. Off-grid technology use is indifferent between the genders.

**The status of clean cooking access does not show significant differences by the sex of household head.** Male heads are a little more likely to adopt LPG stoves than female heads if available. The rate of adopting LPG stoves when they are available is 9.4 percentage points higher for male heads than female heads.

**Female household members are more involved in cooking activities in Rwanda.** While 75.2% of female household heads are cooking for their family every day, the rate is only 6.6% for male heads, and 70.7% of male heads never cook for their families. Also, female household members spend on average 86 minutes on cooking per day, but male members spend only 17 minutes per day, which shows that female household members will benefit the most from improving cooking environment.

## 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): Mahama and Nyabiheke camps in the East Province, Kigeme and Kiziba camps in the West Province, and Mugombwa camp in the Southern Province.

*Access to Electricity*

**Across the five refugee settlements in Rwanda, 38.3% of households have access to at least one electricity source**, which is lower than the access of households in host communities surrounding the refugee camps, 57.4%. While many households in host communities rely on the national grid as their primary electricity source, **refugee households mostly depend on off-grid solutions (37.9%), especially solar lanterns (17.6%) and other solar lighting systems (13.1%).**

**By camp, Mugombwa and Kigeme have relatively low electricity access.** Camps except for Kiziba and Nyabiheke show a major disparity in their access compared to their host communities. Of all camps, Nyabiheke uses SLSs the most, and Mahama is the highest in their use of solar lanterns.

**Only about 15% of refugee households have Tier 1 level access or above** based on the MTF measurement although 38.3% of refugee households have at least one electricity source. 23.7% of refugee population fall into Tier 0 despite their connection to solar technologies.

**Of refugee households with electricity sources, the highest share of refugee households, 34.7%, live with four to eight hours of electricity during the whole day, and 19.9% have less than four hours of electricity.** Refugee households use primarily low-load electrical appliances, and phone chargers are the most common appliances.

Most refugee households use just one solar device. **Many refugee households paid for their main solar devices rather than obtaining them for free.** Among households using solar lanterns, lump sum payment is the most common for their purchase, while households using SLSs often pay in installments.

As the most serious problem of main solar devices, the highest share of refugee households reported short duration of service and not being able to power large appliances for both solar lanterns and SLSs, respectively. Almost 20% of households using solar lanterns answered that their devices break down too often, and among households using SLSs, almost 10% raised the same issue as the most serious problem with their devices.

*Access to Clean Cooking*

**In refugee camps, 62.1% of refugee households have access to clean stoves, more specifically LPG stoves.** The rate is significantly higher compared to non-refugee households; LPG stoves are used by only 4% of general Rwandan households and 0.3% of host community households. Among refugee settlements, LPG stove use is observed only in Mahama and Mugombwa where UNHCR distributed LPG stoves to replace the use of firewood, and refugee households in the rest camps rely on biomass stoves.

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

# MEASURING ENERGY ACCESS IN RWANDA

Without energy, promoting economic growth, overcoming poverty, and supporting human development are challenging, if not impossible. Energy access is thus a precondition to many development goals. Indeed, sustainable energy is the seventh of the 17 UN Sustainable Development Goals (SDGs): 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 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 fast-growing low income countries in Sub-Saharan Africa. Gross domestic product (GDP) of Rwanda steadily increased from the early 2000s, and in 2021, it reached 11.1 billion current US-dollar (“GDP (Current US$) - Rwanda,” n.d.). The annual GDP growth of 2020/2021 was 10.9% (“GDP Growth (Annual %) - Rwanda,” n.d.). Electricity access in Rwanda rapidly improved entering the 2010s. In 2014, 19.8% of the population had electricity access (“Access to Electricity (% of Population) - Rwanda,” n.d.), and in 2016, the rate increased to 28.6% according to the MTF energy access survey from 2016 (Koo et al. 2018). In 2022, the second MTF energy access survey implemented in Rwanda showed that 63.9% of Rwandan households have access to at least one source of electricity, which substantially grew compared to 2016.

## MULTI-TIER FRAMEWORK GLOBAL SURVEY

The World Bank, with the support from the Energy Sector Management Assistance Program (ESMAP), has launched the Global Survey on Energy Access, which aims at providing more nuanced data on energy access, including access to electricity and cooking services. The first phase is being carried out in 16 countries across Africa, Asia, and Latin America.

The survey is analyzed with the MTF approach that goes beyond the traditional binary measurement of energy access—for example, having or not having a connection to electricity, using or not using clean fuels in cooking—to capture the multi-dimensional nature of energy access and the vast range of technologies and sources that can provide energy access, while accounting for the wide differences in user experience.[[1]](#footnote-1) The approach measures energy access provided by any technology or fuel based on a set of attributes that capture key characteristics of the energy supply that affect the user experience. Each attribute is assessed separately in tiers, and the lowest applicable tier attained among the attributes is the aggregate tier of a household, which tells the households’ level of access ranging from Tier 0 (no access) to Tier 5 (full service) (Bhatia and Angelou 2015).

A key issue that the MTF survey explores is the nature of the barriers that prevent a household from moving to a higher tier for access to electricity and clean cooking. This is the value added of the MTF survey. By capturing full-spectrum data, it empowers policy makers to pursue data-informed energy policies and to design interventions that remove barriers, so households can graduate to higher tiers.

### ACCESS TO ELECTRICITY

The value of access to electricity for households is defined by analyzing the seven electricity attributes based on survey responses:

* **Capacity** (“What appliances can be powered?”): The capacity of the electricity supply (or peak capacity) is the ability of the system to provide a certain amount of electricity to operate various appliances, ranging from a few watts for light-emitting diode (LED) lights and mobile phone chargers to several thousand watts for space heaters or air conditioners. First, appliances are classified into tiers based on their power ratings (Table 1). Then each household’s appliance tier is determined by the highest tier of all its appliances; that is, if a household owns multiple appliances, the highest-capacity appliance determines the household tier.[[2]](#footnote-2) Capacity is measured in watts for grids, mini-grid, and fossil fuel generators, and in watt-hours for rechargeable batteries and off-grid solar devices (See Box 1 for a typology of off-grid solar devices). It may be difficult to determine the Capacity of the system by simple observation. An estimate of available Capacity may be based on the supply source (for example, grid power is considered ≥2,000 watts) or the appliances used (Table 1).
* **Availability** (“Is power available when needed?”): The availability of supply refers to the amount of time during which electricity is available. It is measured through two indicators: the total number of hours per day (24-hour period) and the number of evening hours (the four hours after sunset) during which electricity is available.
* **Reliability** (“Is service frequently interrupted?”): The reliability of electricity supply is a combination of the frequency and the duration of unexpected disruptions. In this report, the Reliability attribute is measured only for households connected to the grid.
* **Quality** (“Will voltage fluctuations damage appliances?”): The quality of the electricity supply refers to the absence of severe voltage fluctuations that can damage a household’s appliances. Electric appliances generally require a certain level of voltage to operate properly. Low or fluctuating voltages can damage appliances and even result in electrical fires. A low or fluctuating voltage supply tends to result from an overloaded distribution system or from long-distance, low-tension cables connecting spread-out households to a singular grid. The MTF survey does not measure voltage fluctuation directly but uses incidents of appliance damage as a proxy. In this report, the Quality attribute is measured for households connected to the grid or mini-grid.
* **Affordability** (“Can a household afford the minimum amount of electricity?”): The Affordability of the electricity service is determined by comparing the price of a standard electricity service package (one kilowatt-hour (kWh) of electricity per day or 365 kWh per year) with household expenditure. The price of the package is determined from the prevailing lifeline tariff. If the household spends more than 5% of household expenditure on electricity, then electricity service is considered unaffordable for that household.
* **Formality** (“Is grid electricity provided through a formal connection?”): If households use electricity service from the grid but do not pay anyone for the consumption, their connection could be defined as an informal connection. The Formality of the grid connection is important since it ensures that the electricity authority is paid for the services provided, besides providing for the safety of electric lines. A grid connection is considered formal when the bill is paid to the utility, a prepaid card seller, or an authorized representative. Informal connections pose a significant safety risk and affect the financial sustainability of the utility. Reporting on the Formality of a connection is challenging. Households may be sensitive about disclosing such information in a survey. The MTF survey therefore infers information on Formality from indirect questions that respondents may be more willing to answer such as what method a household uses to pay its electricity bill.
* **Health and Safety** (“Is it safe to use an electricity service?”): This attribute refers to any injuries to household members from using electricity during the preceding 12 months of the survey. An injury could mean limb injury or even death from burn or electrocution. Such injuries can happen not just from faulty internal wiring (exposed bare wire, for example) but also from incorrect use of electrical appliances or negligence; however, the MTF analysis does not make a distinction between the two. Electricity access is considered safe when users have not suffered from past accidents due to their electricity supply resulting in permanent injuries.

In the analysis of the MTF Rwanda survey, access to electricity access was measured with six attributes: capacity, availability, reliability, quality, formality, and safety. For each of these attributes, households are placed in a tier depending on the level of service as defined by the different thresholds. (See Figure 7 for thresholds in the multi-tier matrix for measuring access to electricity.) The lowest tier value households obtain among the attributes becomes their aggregate electricity tier reflecting their level of electricity access.

Households falling into Tier 0 as their aggregate electricity tier classification receive electricity for less than 4 hours a day (or less than one hour per evening) or have a primary energy source with a capacity of less than 3 watts. (See Box 2 for the minimum requirements, by tier of electricity access.) Tier 1 refers to households with limited access to small quantities of electricity provided by any technology, even a small solar lighting system, for a few hours a day, enabling electric lighting and phone charging.

Table 1: Appliances by Load Level and Associated Capacity Tiers

테이블이(가) 표시된 사진

자동 생성된 설명

*Source: Bhatia and Angelou 2015*

Box 1: Typology of Off Grid Solar Devices and Tier Calculation

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| --- |
| In the analysis of this report, solar devices are classified into three types based on the number of light bulbs and the type of appliances or electricity services a household uses: solar lanterns, other solar lighting systems (SLSs) and solar home systems (SHS)[[3]](#footnote-3). This typology is also used to measure electricity access with the MTF approach, especially the Capacity attribute.   * **Solar lanterns** power a single light bulb and could possibly power radio and/or phone charging. Under the MTF methodology, the capacity tier of a solar lantern is calculated based on the household size to capture the number of household members relying on the service and the ability to power radio and/or phone charging. * **Solar lighting systems (SLSs)** power two or more light bulbs and could possibly power radio and/or phone charging, but SLSs cannot power any other appliances. The capacity tier of a SLS is calculated based on the household size and the ability to power radio and/or phone charging. * **Solar home systems (SHSs)** power two or more light bulbs and appliances such as televisions, irons, microwaves, or refrigerators. (See Table 1 for the load level associated with each Capacity tier.) |

Box 2: Minimum Electricity Requirements, by Tier of Electricity Access



*Source: Bhatia and Angelou 2015*

### ACCESS TO MODERN ENERGY COOKING SERVICES

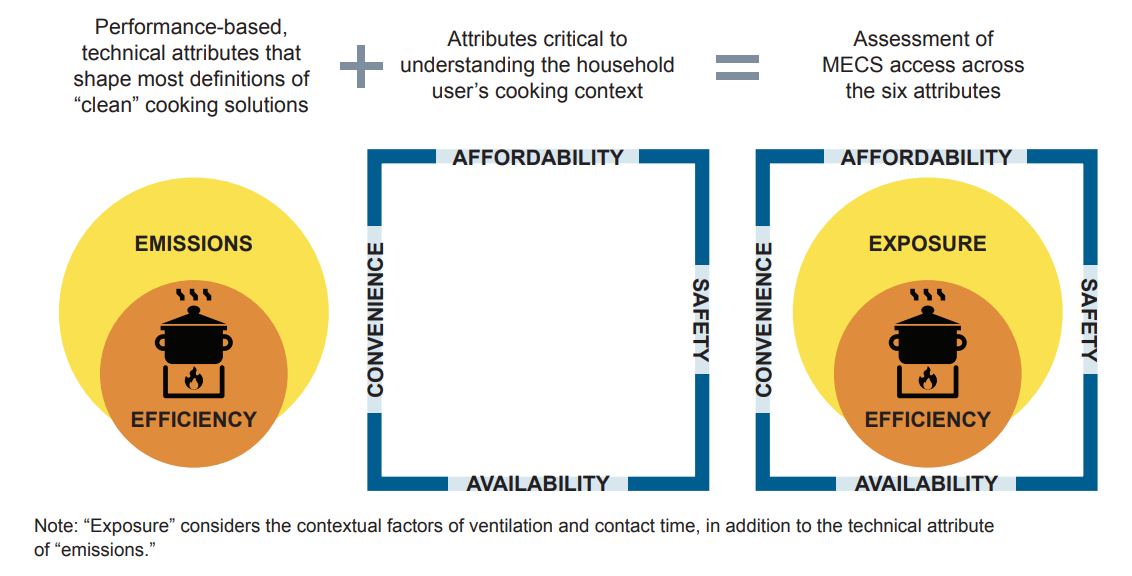
Progress on Sustainable Development Goal 7.1 access to clean cooking fuels and technologies has been slow with around 2.8 billion of the world’s population still using polluting and inefficient cooking solutions (International Energy Agency (IEA) et al., 2020). The inefficient use of solid fuels has significant impacts on health, socioeconomic development, gender equality, education, and climate (Ekouevi and Tuntivate 2012; United Nations Development Programme (UNDP) and World Health Organization (WHO) 2009)[[4]](#footnote-4). The consequences of inefficient energy use for cooking extend beyond direct health impacts. Such use also affects socioeconomic development; for example, fuel collection and cooking tasks are often carried out by women and girls. Collection time depends on the local availability of fuel and may reach up to several hours a day (Energy Sector Management Assistance Program (ESMAP) 2004; Gwavuya et al. 2012; Parikh 2011; Wang et al. 2013). The time spent on fuel collection and preparation often translates into lost opportunities for gaining education and increasing income (Blackden and Wodon 2006; Clancy, Skutsch, and Bachelor 2003). In addition, the associated drudgery increases the risk of injury and attack (Rehfuess, Mehta, and Prüss-Üstün 2006).

The MTF measures access to modern energy cooking services (MECS) based on six technical and contextual attributes that consider users’ cooking experience, environment, and the market and energy ecosystems in which they live (BOX 3): (i) exposure, (ii) efficiency, (iii) convenience, (iv) safety, (v) affordability, and (vi) fuel availability (Energy Sector Management Assistance Program (ESMAP) 2020).

* **Cooking Exposure** Personal exposure to pol­lutants, which depends on both stove emissions and ventilation (Higher tiers indicate lower exposure.)
* **Efficiency** Combination of combus­tion and heat-transfer efficiency
* **Convenience** Time spent collecting/ purchasing fuel and preparing the stove
* **Safety** Severity of injuries caused by the stove over the past year
* **Affordability** Share of household budget spent on fuel (Higher tiers indi­cate lower share of spending.)
* **Availability** Readiness of the fuel when needed

In the analysis of the MTF Rwanda survey, access to clean cooking was measured with the 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 55 for detailed metrics).

Box 3: Holistic Criteria to Measure Access to Modern Energy Cooking Services



*Source: Energy Sector Management Assistance Program (ESMAP) 2020*

Box 4: MTF Attributes showing tiered progress towards access to Modern Energy Cooking Services

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| --- |
| **Modern Energy Cooking Services** refers to a household context that has met the standards of Tier 4 or higher across all six measurement attributes of the Multi-Tier Framework |

*Source: Energy Sector Management Assistance Program (ESMAP) 2020*

**Improved Cooking Services** refers to a household context that has met at least the Tier 2 standards of the MTF across all six measurement attributes but not all for Tier 4 or higher. Household contexts with a status of MTF Tier 2 or Tier 3 are considered in Transition.

Box 5: Rwanda Cookstove Typology

|  |
| --- |
| Cookstoves in Rwanda are classified into following categories (Annex 6):  **Three-stones/open fire stoves** consist of a pot balanced on three stones. The pot sits on the flames and the fuel rests on the ground. In general, this stove uses firewood and has a low combustion temperature; Its fire is exposed to cold wind causing the heat to be lost to the ambient air.  **Traditional stoves** (biomass, artisan or self-built stoves) typically use conventional material to insulate the fire, and the pot rests above the flames. It is also produced locally using available, low-cost materials and fuels, reflecting cultural practices.  **Improved cook stoves** (biomass manufactured stoves): The conventional improved cookstove is a wood, charcoal or pellet stove with an insulated combustion chamber. The pot resides above the fuel.  **Kerosene cookstoves** use kerosene or Liquid as fuel.  **Clean fuel stoves** use clean and efficient fuels, such as liquefied petroleum gas (LPG), electricity, or biogas |

## USING THE MULTI-TIER FRAMEWORK TO DRIVE POLICY AND INVESTMENT

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

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

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

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

## MULTI-TIER FRAMEWORK SURVEY IMPLEMENTATION IN RWANDA

The Rwanda MTF survey implemented in June 2022 consisted of field surveys interviewing households and public institutions on electricity access and clean cooking along with socioeconomic backgrounds.

**Survey Sampling**

1. Household Survey

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

*Nationally Representative Sample*

To have a nationally representative sample, the 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 (NISR) was used for the sampling frame. Enumeration areas (EA) 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, the rest of EAs in the entire sampling frame.

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 listing, households in the EAs were stratified into electrified and non-electrified households. Predetermined number of households of 18 were randomly selected in each EA, and the households were expected to be 50% grid-electrified and 50% non-grid-electrified. In this report, responses from 4,000 non-host community households were analyzed.

To sample host communities, in total, 56 EAs were randomly selected among the communities within 5 Km of each camp, and then in each village, 18 households were randomly selected (Table 3). Responses from 1,006 households in host communities were analyzed.

Table 2. Distribution of the Sample Household by Province and Locality

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Province | Allocation of Sample Villages | | | Household Allocation | | |
| **Urban** | **Rural** | **Total** | **Urban** | **Rural** | **Total** |
| Kigali City | 39 | 10 | 49 | 702 | 180 | 882 |
| South | 18 | 27 | 45 | 324 | 486 | 810 |
| East | 21 | 24 | 45 | 378 | 432 | 810 |
| North | 16 | 22 | 38 | 288 | 396 | 684 |
| West | 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 implemented in all five refugee camps in Rwanda: Mahama and Nyabiheke camps in the East Province, Kigeme and Kiziba camps in the West Province, and Mugombwa camp in the Southern Province. The list of segments in the refugee camps and the size of population per segment was provided by the United Nations High Commissioner for Refugees (UNHCR) Rwanda, and the 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, and in each segment, 18 refugee households were randomly selected (Table 3). In the report, responses from 700 refugee households were analyzed.

Table 3. Sample Distribution for Refugee Camps and Hosting 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** |
| *Source: CESS Ltd. 2022a* | | | | |

The spatial distribution of household samples can be found in Map 1.

Map 1. Distribution of Households Sampled for the Multi-Tier Framework Survey in Rwanda

지도이(가) 표시된 사진

자동 생성된 설명

*Source: “Distribution of Households Sampled for the Multi-Tier Framework Survey in Rwanda” 2023*

1. Public Institutions Survey

For the public institutions survey, health facilities and education facilities were interviewed. All health centers and education facilities in the selected villages from the first stage stratification of the household survey were targeted and interviewed as samples for the public institutions survey. In total, 196 education centers and 281 health facilities across Rwanda were interviewed and analyzed.

# ACCESS TO ELECTRICITY

# HOUSEHOLD ACCESS TO ELECTRICITY

## Assessing Access to Electricity

## **Electricity Access by Technology**

## *Nationwide*

As of mid-2022, nationwide 63.9% of Rwandan households have access to at least one source of electricity[[5]](#footnote-5), which increased by 35.3 percentage points compared to the access rate from the 2016 MTF survey (Koo et al. 2018) (Figure 1). Rural areas show a larger increase in their electricity access than urban areas do. In 2022, 57.9% of rural households have access to electricity sources, which improved by 40.4 percentage points from 2016. In urban areas, 91.6% of households have at least one electricity source in 2022, while the rate was 78.7% in 2016. Rural areas and urban areas still show major disparities in their electricity access by 33.7 percentage points in 2022, which stresses the importance of prioritizing rural electrification.

Figure 1. Rwanda Electricity Access, by locality (2016 vs 2022)

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

In Rwanda, almost half of households have access to the national grid as their main electricity source, which increased more than twice compared to 2016 (Figure 2). The use of the national grid highly increased particularly in rural areas. In 2022, 42.2% of rural households use the national grid, which grew by 29.7 percentage points compared to 2016. In urban areas, the increase in grid access was 13.5 percentage points with 89.3% of households using the grid in 2022. Despite the significant improvement in grid access among rural households, their grid rate is still less than half of the urban households’ rate.

Off-grid technologies serve as effective electricity sources for rural households based on the noticeable increase in their use. [[6]](#footnote-6) In 2016, only 5% of rural households relied on off-grid solutions, while in 2022, the proportion increased to 15.7% (Figure 2). In urban areas, the adoption of off-grid solutions is negligible in 2022, and the rate has not significantly changed from 2016.

Among off-grid solutions, solar devices are widely adopted. Households using either solar lanterns, other solar lighting systems or solar home systems for their main electricity source account for 12.4% nationwide, and solar lighting systems are the most used by 7.6% of households (Figure 3). In rural areas, 14.6% of households rely on solar solutions, which is 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; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 3. Off-grid Technology Distribution, by locality (2022)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## *By Province*

Across all provinces in Rwanda, the national grid is the most prevalent electricity source. Households relying on the grid as the primary electricity source are the highest in Kigali City where the capital of Rwanda is located. In Kigali City, 93.8% of households use the grid, while in all other provinces, the proportion is much lower (Figure 4). In the Eastern province, 54% of households use the national grid as their main source of electricity, and in the Southern, Western and Northern provinces, less than half of the population do. This shows that future grid expansions should be more distributed to regions other than Kigali City.

Off-grid solutions are commonly used in most provinces other than Kigali City (Figure 4). The Eastern Province has the highest share of households of 18.6% relying on off-grid technologies. Across provinces, the most common off-grid technology is solar lighting systems other than solar lanterns, and their adoption does not show substantial differences by region (Figure 5). The use of solar home systems is slightly higher in the Eastern Province than in other provinces, but overall, a small number of Rwandan households use the solution.

The Southern, Western, and Northern provinces are the regions with specifically low electricity access. While the proportion of households without electricity is 5.4% in Kigali City and 27.4% in the Eastern province, the share is above 40% in the Southern, Western, and Northern provinces (Figure 4). Targeting specifically the three lagging provinces to increase electricity access is crucial.

Figure 4. Provincial Electricity Access, by technology

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 5. Off-grid Technology Distribution, by province

|  |
| --- |
|  |

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## *By Ubudehe Category*

In Rwanda, a socio-economic categorization mechanism called Ubudehe is used to determine households’ eligibility for Rwanda’s social protection interventions including public works, direct support, community-based health insurance and education grants (Rwanda Ministry of Local Government 2018). Under the Ubudehe practice, households are periodically categorized according to their perceived poverty and vulnerability status by their communities (National Institute of Statistics of Rwanda (NISR) 2015). When the survey was implemented, there were four Ubudehe classifications from Category 1 to 4 in ascending order: Category 1 being the most socio-economically vulnerable and Category 4 the least. In this report, analysis based on Ubudehe categorization included households in Category 1 to 3 only due to data limitations.

The analysis shows that Ubudehe categorization is strongly correlated with electricity access and access to the grid. Not surprisingly, when the Category rises, the percentage of households connected to the national grid increases, but the share of households without any electricity sources declines (Figure 6).~~.~~

Figure 6. Access to Electricity Technologies, by Ubudehe categories

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## **Electricity Access Based on the Multi-Tier Framework (MTF)**

## Household Distribution by MTF Tier

In the MTF measurement of electricity access in Rwanda, households’ level of electricity access is assessed based on six attributes in Figure 7, and the lowest Tier score among the six becomes the households’ final Tier classification, or the aggregate electricity Tier. Households above Tier 0 in all attributes are classified above aggregate electricity Tier 0, and it represents that the households have electricity access though its level and quality might need improvements. Households falling into aggregate electricity Tier 0 hardly have electricity access. They have the tier from either not owning electricity sources at all or having Tier 0 in the Capacity attribute and/or Availability attribute, which means that the electricity capacity and/or availability are/is too poor to count as having electricity access (Figure 7). In following paragraphs, Rwandan household distributions based on the aggregate Tier will first be presented, and the tier distribution by each attribute will be discussed.

Figure 7. The Multi-Tier Framework Electricity Tier Matrix for Rwanda Survey Analysis

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Attributes** | | **Tier Score** | | | | | |
| Tier 0 | Tier 1 | Tier 2 | Tier 3 | Tier 4 | Tier 5 |
| Capacity | | < 3W | 3W-49W | 50W-199W | 200W-799W | 800W-1999W | ≥ 2kW |
| 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 per week)* | | - | | | Disruptions > 14 | (4-14 disruptions)  OR  (≤ 3 disruptions &  ≥ 2 hrs duration) | (Disruptions ≤ 3)  AND  (duration < 2 hrs) |
| Quality | | - | | | With voltage issues | - | No voltage issues |
| Formality | | - | | | Informal | - | Formal |
| Safety | | - | | | Had past accidents | - | Safe, no accidents |
| Note: Each attribute has a different Tier score range. Gray areas in the table means they are not in the score range. | | | | | | | |
| *Source: Bhatia and Angelou 2015* | | | | | | | |

**Aggregate Electricity Tier**

The MTF analysis shows that as of 2022, nationwide 58.9% of Rwandan households have electricity access falling into Tier 1 or above for their final tier classification (Figure 8). Compared to 2016, the share of households in the same tier range increased by 32.1 percentage points in 2022. Nationwide 41.1% of Rwandan households are still Tier 0 in 2022 and hardly have electricity access.

Rwandan households in higher aggregate Tiers mostly rely on the national grid as their main electricity source, while those in lower Tiers mainly use solar devices. As Figure 9 shows, households with Tier 3 or higher predominantly adopt the national grid. Despite the grid connection, some households fall between Tier 2 and 4, which indicates that households experience quality problems with their grid electricity.

Many households classified as Tier 1 and 2 rely on solar technologies (Figure 9). Among Tier 2 households, 58.3% of households use solar home systems as their primary electricity source, and 88.6% of Tier 1 households adopt solar lighting systems other than solar lanterns. Most Tier 0 households do not have any source of electricity, and about 12% use electricity from solar devices with limited capacity and/or availability.

Figure 8. Nationwide Household Distribution Based on Aggregate Electricity Tier

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 9. Electricity Technology, by Aggregate Electricity Tier (2022)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

The Tier distribution by locality shows that electricity access in rural areas improved markedly by 2022 compared to 2016, but a large disparity remains between rural and urban areas. In 2022, 51.9% of rural households have electricity access falling into Tier 1 or above for their final tier classifcation, which increased by 36.3 percentage points from 2016 (Figure 10). In urban areas, the rise was 13.5 percentage points. Although rural areas had the biggest improvement over time, the proportion of households with electricity access is still 39 percentage points lower than urban areas.

Figure 10. Household Distribution Based on Aggregate Electricity Tier (Rural/Urban)

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

The gap in the level of electricity access between Kigali City and the rest provinces of Rwanda is considerable. In Kigali City, 94.5% of households are classified above aggregate Tier 0, while in Eastern province, households with electricity access account for a much lower 66.3%, and in all other provinces, the share is only around 50% (Figure 11).

Figure 11. Provincial Household Distribution Based on the Aggregate Electricity Tier

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

**Capacity**

The Capacity attribute represents the ability to provide electricity to power various appliances. As of 2022, in Rwanda, capacity is more of a problem for rural areas. As shown in Figure 12, while almost 90% of urban households have high capacity with 2 kilowatts or above, the share is only 51% in rural areas. The high proportion of rural households below Tier 3 of the Capacity attribute are mostly those without any electricity sources and those using off-grid solar solutions with limited capacity (Figure 13). For the lack of Capacity attribute data from 2016, changes in the Tier distributions over time were not captured.

Figure 12. Distribution of Households Based on Capacity Tier, by locality (2022)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 13. Electricity Technology Distribution in Rural Areas, by Capacity Tier

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

**Availability**

The Availability attribute shows electricity availability of households with at least one source of electricity. It captures electricity availability during the whole day and specifically in the evening from 6pm to 10pm. For many Rwandan households, electricity availability during the whole day improved in 2022. As Figure 14 shows, nationwide 71.8% of Rwandan households with electricity access live with at least 23 hours of electricity per day in 2022, which increased by 22.2 percentage points from 2016. Most households with such long hours of electricity supply use the national grid as their main electricity source (Figure 15). By locality, in both rural and urban areas, the share of households with 23 hours of electricity or more during the whole day noticeably increased in 2022 (Figure 16).

In the evening, available hours of electricity also increased in 2022 compared to 2016, but the improvement is smaller than the changes occurred for all-day availability. As Figure 17 shows, in 2022, nationwide 78.2% of households have four hours of electricity in the evening, which increased by 6.3 percentage points compared to 2016.

Figure 14. Nationwide Household Distribution Based on the Day Availability Tier

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 15. Main Electricity Source, by Day Availability Tier (nationwide, 2022)

*Sources: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 16. Household Distribution Based on the Day Availability Tier, by locality

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 17. Nationwide Household Distribution Based on the Evening Availability Tier

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

**Reliability**

The Reliability attribute shows how frequently electricity from the national grid and mini grids is interrupted in a typical week. In Rwanda, electricity reliability improved substantially by 2022 compared to 2016. As shown in Figure 18, by 2022, the proportion of households experiencing more than 14 outages per week disappeared nationwide, and the proportion of households in Tier 5 of the Reliability attribute increased by 20.1 percentage points. More than half of Rwandan households still face four to fourteen electricity interruptions, or less than four but lasting for more than two hours, in a typical week.

**Quality**

The Quality attribute captures voltage quality of electricity from the national grid and mini grids in the past 12 months from the survey period. In Rwanda, the quality of electricity has enhanced, but the improvement is not large. As Figure 19 shows, in 2022, 14.7% of Rwandan households nationwide face voltage fluctuations, which reduced by 6.2 percentage points compared to 2016.

**Formality**

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

**Health and Safety**

This attribute represents electricity safety based on households’ experience of bodily injury or death from electricity in the past 12 months from the survey period. The analysis shows that electricity is generally safe in Rwanda. In 2022, 99.8% of households find electricity safe, which improved by 4.5 percentage points compared to 2016 (Figure 21).

Figure 18. Nationwide Household Distribution Based on the Reliability Attribute

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 19. Nationwide Household Distribution Based on the Quality Attribute

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 20. Nationwide Household Distribution Based on the Formality Attribute

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 21. Nationwide Household Distribution Based on the Safety Attribute

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

## **Use of Electricity**

National Grid

Although access to the national grid substantially grew by 2022 (Figure 2), the average consumption of grid electricity remains low. In 2022, nationwide, Rwandan households consume 16.8 kWh of electricity per month on average (Figure 22), which is lower than the average consumption of nearby East African countries like Kenya with 48.6 kWh and Uganda with 42 kWh (Dubey et al. 2019; Energy Sector Management Assistance Program (ESMAP) n.d.).

Compared to 2016, the nationwide grid consumption is lower in 2022 because of the major grid expansion in rural areas over time. In 2022, 68.3% of Rwandan households connected to the grid are rural households with low average grid consumption of 11.3 kWh (Figure 22). For the high share of rural households with low grid electricity use, the nationwide average of grid consumption in 2022 is lowered.

By locality, urban and rural areas show a big disparity in their electricity consumption. In 2022, urban households consume electricity about 2.5 times more than rural households do (Figure 22). Across Ubudehe categories, urban households show higher grid consumption than rural households do (Figure 23).

Unlike urban households, rural households do not show substantial differences in their grid consumption by Ubudehe classifications (Figure 23). This suggests that for rural households, their wealth level might not be the major factor for their current low grid consumption. Grid consumption tends to rise along with years of connection, but rural households in most Ubudehe categories are connected to the grid in recent five years on average, which would have been too short for grid consumption to increase (Figure 24 and 25).

Figure 22. Monthly Grid Consumption, by locality (kWh)

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 23. Nationwide Monthly Grid Consumption in 2022, by Ubudehe category and by locality (kWh)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 24. Years of Grid Connection, by Ubudehe category and by locality (year)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 25. Nationwide Grid Consumption, by years of grid connection (kWh)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

In 2022, nationwide, Rwandan households spend on average 2,267 Rwandan Franc (RWF), equivalent to around 2 United States Dollar (USD), on grid electricity (Figure 26). Grid expenditure of rural households is 1,164 RWF (~1 USD), while urban households spend almost four times more on the grid.

Grid expenditure markedly dropped from 2016, especially in rural areas (Figure 26). The decrease in rural grid expenditure could be explained by the 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 (Energy Sector Management Assistance Program's Energy Subsidy Reform Facility (ESRF) 2019; Rwanda Utilities Regulatory Authority (RURA) 2015; Rwanda Utilities Regulatory Authority (RURA) 2016). In 2022, the end-user tariff for households consuming less than 15 kWh per months is about half of the tariff in 2016 (Rwanda Utilities Regulatory Authority (RURA) 2015; Rwanda Utilities Regulatory Authority (RURA) 2020). The average monthly consumption of rural households is 11.3 kWh in 2022 as Figure 22 showed, which suggests many rural households would have paid less with the reduced tariff in 2022, and it would have led to decrease in the average rural grid expenditure. Of grid-connected households, the share of rural households is large as previously mentioned, so the drop in the average rural grid expenditure would have led to the sharp decline in the nationwide average.

By Ubudehe categories, while rural households do not show substantial differences in their monthly grid spending, in urban areas, households in Category 2 and 3 show clear distinctions corresponding to their consumption difference described in Figure 23 (Figure 27).

Figure 26. Monthly Grid Expenditure

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 27. Monthly Grid Expenditure, by Ubudehe category and by locality

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Many grid-connected households still use low load devices and do not take advantage of the high capacity available from the national grid. If households are connected to the grid, they fall into the Capacity Tier 5, assumed to have electricity capacity of 2,000W or higher. While nationwide 50.7% of households should have access to the high level of electricity capacity from their grid connection as Figure 2 showed, 68.3% of Rwandan households use devices requiring less than 50W as their highest load level appliance (Figure 28). Households using appliances demanding 2,000W or more account for only 0.8%.

This is specifically the case for rural households. Though 42.2% of rural households are on the grid that would provide high-capacity electricity (Figure 2), 84.2% of rural households use devices with load level less than 50W as their highest load level appliances (Figure 28). In urban areas, appliances with higher load levels are more common for the highest load level device, but only 2.3% households use appliances requiring 2,000W or higher. This could imply that many Rwandan households do not own appliances to take advantage of the capacity level, or households might suppress their appliance use because they cannot afford the electricity payment.

Figure 28. Highest Load Level of Appliances Used by Grid-connected Households

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Compared to rural households, urban households benefit more from available electricity by using more devices at different load levels (Figure 29). In both rural and urban areas, typical mobile phone chargers and compact fluorescent light (CFL) bulbs are the most used electrical appliances (Figure 30). Rural households are particularly high in their use of incandescent light bulbs and dry-cell battery-based torches. On the other hand, urban households show specifically high use of smartphone chargers and electric irons.

Figure 29. Appliance Use of Grid-connected Households, by load level

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 30. Appliance Use of Households Using the National Grid as the Main Electricity Source, by locality

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## Improving Electricity Access

## **Providing Electricity Access to Households without Electricity**

In Rwanda, a lack of electricity access is specifically a problem for rural areas. As Figure 31 shows, 42.2% of rural households do not have any source of electricity, while the proportion is only 8.4% in urban areas. Many households without electricity instead rely on dry cell torches and flashlights (Figure 32).

Figure 31. Rate of Households without Any Source of Electricity

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 32. Nationwide Use of Dry Cell Torch/Flashlight/Lantern, by households' electricity access status

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

In the survey, 18 households were interviewed in each sampled village, and when at least one of the 18 households has access to the national grid, the village was considered to be grid-electrified. Based on the assumption, the survey shows that many villages where households without any source of electricity belong actually have grid availability. In rural areas, 63.8% of villages of households without electricity are grid-electrified, while in urban areas, 96.9% of such villages have grid access (Figure 33).

Figure 33. Grid Electrification Status of Villages with Households without Electricity, by locality

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

The major constraints to gain grid access for Rwandan households without grid connections are distance and expensive initial grid connection cost (Figure 34). Compared to 2016, in 2022, the share of households finding grid connection cost expensive decreased by about 20 percentage points nationwide. Nevertheless, more than one third of households without grid still find the initial connection cost as a barrier in 2022 despite the grid connection policy from 2017, which allowed Rwandan households to apply for a grid connection at no initial cost if they do not need grid network extension and repay the connection fee from power purchase (Rwanda Energy Group 2017).

If limited to households without any source of electricity, in both rural and urban areas with grid availability[[7]](#footnote-7), the highest share of households is not connected to the grid because of the expensive connection fee (Figure 35). This could indicate that the connection cost is still a burden to households even if they can spread their payment as the policy from 2017 allows. It could also imply that many households are still not aware of the connection policy.

Figure 34. Why Households Are Not Connected to the Grid (nationwide)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 35. Why Households without Any Electricity Sources Are Not Connected to the Grid in Villages with Grid Availability

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

In rural villages without grid availability, distance is the barrier for grid connection for the highest share of households without any source of electricity (Figure 36). These households might live in remote areas without grid infrastructures at all, or the high connection cost from living far from the grid would have prevented them from having the connection. Since households residing beyond the standard connection distance should pay the cost for the electricity network extension as well, distance would have been the problem for households (Rwanda Energy Group 2017).

Figure 36. Why Households without Any Electricity Sources Are Not Connected to the Grid in Villages without Grid Availability

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Households without electricity were asked if they are willing to pay for solar home systems with different capacity levels randomly assigned to them at different price points (Annex 4). Not surprisingly, households are more likely to purchase a solar home system at all types of payment plans when lower price points are offered (Figure 37). When the high-capacity solar home system with a higher price range is offered, major populations are never willing to pay for it. The share of households willing to pay in installments remains low and does not significantly change when price points are high. Of households never willing to pay for the solar devices offered, 96.2% did not accept the offer because they cannot afford the payment (Table 4). To offer off-grid solar solutions to households without electricity sources, means to relieve the price burden on households should be entailed.

Figure 37. Unelectrified Households’ Willingness to Pay for Solar Devices (nationwide)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Table 4. Why Households Would Never Accept the Offer

|  |  |
| --- | --- |
| **Why not accepting the offer?** | |
| Cannot afford the payment. | 96.2% |
| I already have electricity to meet my needs. | 1.4% |
| Maintenance/servicing of device is not available. | 0.8% |
| Other | 1.5% |

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## **Improving Access to the National Grid**

## Challenges with Electricity from the National Grid

Many grid-connected households do not find major issues with their grid electricity, but the quality of grid electricity and its costs are concerns for some households. As Figure 38 shows, more than half of the grid-connected households do not find problems with their electricity, but 20.2% of households on grid reported unpredictable interruptions as the most serious problem with the national grid. More than one out of ten grid-connected households find electricity too expensive, and 7.3% of households consider voltage fluctuations to be the most serious issue.

Figure 38. The Most Serious Problems with Electricity from the National Grid

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

In line with problems identified in Figure 38, electricity interruptions are common for many Rwandan households connected to the national grid. As Figure 39 describes, among households using the national grid as the main electricity source, 57% face either four to 14 outages per week or experience less than four interruptions lasting longer than two hours. Across provinces, the proportion of households in Tier 4 of the Reliability attribute is similar, but it is comparatively higher in the Southern province and the Western province (Figure 40). Voltage fluctuation is also a problem for some households. Nationwide about 15% of Rwandan households on grid experience voltage issues based on the Quality Tier distribution in Figure 41.

Figure 39 Figure 40. Distribution of Grid-connected Households Based on the Reliability Tier

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 40 Figure . Distribution of Grid-connected Households Based on the Reliability Tier, by province

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 41 Figure 41. Distribution of Grid-connected Households Based on the Quality Tier

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

When households experience grid outages, they mainly rely on mobile phone lights, dry cell lighting sources and candles as the back-up source for lighting. As shown in Figure 42, nationwide the highest proportion of households use mobile phone lights, and dry-cell battery/rechargeable torches and candles are used by 21.4% and 16.8% of households respectively.

Figure 42. Nationwide Backup Sources for Lighting

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## Challenges with Electricity from Solar Solutions

Short duration of electricity service, poor quality of light and low power capacity are the major concerns with all types of solar devices (Figure 43). The proportion of households facing the issues is slightly lower for the case of solar home systems compared to the other technologies, but some households using solar home systems suffer instead from the burden from recurrent costs related to the devices.[[8]](#footnote-8) Specifically, 16.7% of households using solar home systems have the cost problem, which is about 11 percentage points higher than the share of households using solar lanterns and solar lighting systems each.

Figure 43. Problems with Households' Main Solar Devices

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Box 6. Electricity Access in Public Institutions in Rwanda

|  |
| --- |
| In Rwanda, electricity access of education and health facilities is high overall, but education centers show relatively lower electricity access. As shown in Figure 44, nationwide 100% of health facilities are electrified, but the access rate of education facilities is 13.7 percentage points lower. The use of grid electricity is prevalent among both public institutions, while off-grid solar solutions are more used by education facilities. 14.4% of Rwanda schools rely on solar technologies, which is 12.9 percentage points higher than the solar rate of health facilities.    Figure 44. Electricity Access of Public Institutions, by technology  *Source: “Multi-Tier Framework Survey in Rwanda” 2022* |

# POLICY RECOMMENDATIONS

**Prioritize rural electrification and expand electricity access in provinces other than Kigali City.**

While Rwanda achieved significant improvement in electricity access by 2022 especially in rural areas, the survey shows that the major disparity in electricity access between urban and rural areas still exists. To close the gap, rural electrification should be prioritized.

By province, the survey demonstrates that while Kigali City shows high electricity access with high access to the national grid, all other provinces are comparatively lagging in their electricity access. This suggests that future grid expansions should be more distributed to regions other than Kigali City, and electricity access should be expanded in Southern, Western, and Northern provinces with relatively low access.

**Address affordability barriers for connections to the national grid.**

While the share of households reporting initial connection cost as a barrier for grid connection decreased compared to 2016, in 2022, still more than one third of households without grid connection report the barrier despite the policy from 2017, which allows applying for a grid connection at no initial cost and repay the connection fee from power purchase (Rwanda Energy Group 2017). This suggests that the current connection cost should be further studied to assess if it is too expensive to afford even if households can spread their payment. Households might not be aware of the connection policy from 2017; therefore, advertising the policy to households would be crucial.

# ACCESS TO MODERN ENERGY COOKING SERVICES

## Assessing Access to Modern Energy Cooking

## **Modern Energy Cooking Access by Technology**

## *Nationwide*

In Rwanda, clean cooking practices are still not widespread. As Figure 45 shows, the use of three-stones/open fire stoves and traditional/locally built stoves as the primary method of cooking are prevalent nationwide, and clean cooking solutions such as LPG stoves and electric stoves are hardly used.[[9]](#footnote-9) Rural and urban areas show big differences in their stove choices. While a high proportion of the rural population relies on three-stones/open fire stoves and traditional stoves as their main stoves, more advanced manufactured biomass stoves are adopted by major urban households (Figure 45). Also, in urban areas, the penetration of clean cooking solutions significantly increased in 2022 unlike in rural areas. In 2016, only 1.7% of urban households used LPG stoves, but in 2022, 19% of households adopt them as their primary stoves (Figure 46).

Figure 45. Primary Cookstove, by locality (2022)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 46. Use of LPG Stoves

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

## *By Province*

Clean stoves are adopted mainly in Kigali City. As shown in Figure 47, in Kigali City, 23.8% of households cook with LPG and electric stoves as their primary method of cooking, and 46.4% of households use manufactured biomass stoves. In contrast, in all other provinces, three-stones/open fire stoves and traditional stoves are predominant, and clean stoves are insignificantly used. Campaigns to advertise and introduce clean cooking practices should focus more on areas outside of Kigali City.

Figure 47. Primary Cookstove, by province

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## *By Ubudehe Categories*

Clean stove use is positively correlated with Ubudehe classifications. Households in higher Ubudehe categories tend to show higher use of LPG stoves and manufactured biomass stoves as their main stoves (Figure 48). On the other hand, three-stones/open fire stoves and traditional stoves are more adopted by households in lower Ubudehe categories.

Figure 48. Primary Cookstove, by Ubudehe Categorization

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

For fuels for cookstoves, wood is heavily consumed in rural areas, while charcoal is widely selected in urban areas (Figure 49). As Figure 45 described, since many rural households adopt three-stones/open fire stoves and traditional stoves that mainly burn firewood (Figure 50), wood use is high in rural areas. A high share of rural households collect wood rather than purchasing it (Figure 49). On the other hand, in urban areas where manufactured biomass stoves are more prevalent, charcoal consumption is high (Figure 45, Figure 49 and Figure 50).

Figure 49. Fuels for Primary Stoves, by locality

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 50. Fuels Use, by Primary Stoves

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Box 7. Stove Use of Education Facilities in Rwanda

|  |
| --- |
| Nationwide 98.8% of Rwanda schools preparing meals use just one cookstove, and stoves built-in place burning firewood are predominant. As shown in Figure 51, 80.7% of Rwanda schools use built-in place stoves. Regardless of stove type, all education facilities use firewood for their stoves. In a month, schools spend on average 129,087 RWF (~126 USD) on firewood, and the average consumption is 14.4 Stere.  Figure 51. Primary Cookstove of Education Facilities, nationwide  *Source: “Multi-Tier Framework Survey in Rwanda” 2022* |

## **Stove Stacking**

Households’ stacking more than one cookstove could reflect households’ desire to transition to better performing stoves or the need of back-up cookstoves. Stove stacking is not common in Rwanda, and most households own just one stove. Only 11.6% of households have two cookstoves stacked, and the proportion of households stacking three stoves is negligible (Figure 52). In urban areas, the stacking practice is more common than in rural areas. The share of urban households with two stoves is roughly two times higher than that of rural households.

Figure 52. Number of Cookstoves Stacked, by locality

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Nationwide traditional stoves and manufactured biomass stoves are the most common stoves stacked by households with two stoves (Figure 53). LPG stoves are stacked by only 10.1% of households. In rural areas, the highest share of households stacks traditional stoves, while in urban areas, manufactured stoves and LPG stoves are widely kept aside.

Figure 53. Stacked Stoves of Two-stove Households

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Among two-stove households, some households transitioned to a better performing cookstove, but some remain with a lower performing stove due to the expensive fuel cost. As Figure 54 shows, among households stacking traditional stoves, 60.4% cook with manufactured biomass stoves as their primary stove. In this case, households transitioned to a more advanced cookstove. However, 33.3% use three-stones/open fire stoves for their main stove, which are likely to have lower performance. Among households keeping manufactured biomass stoves aside, almost one third of the households transitioned to better performing LPG stoves for their primary stoves, while the rest rely on lower performing stoves. All households stacking LPG stoves use a stove with lower performance as their primary method of cooking.

Expensive fuel cost is the major barrier for households that remain with a lower spec cookstove although they own a better one. The survey shows that all households stacking traditional stoves and LPG stoves and 99.6% of those stacking manufactured biomass stoves do not use them most of the time due to the expensive fuel. This suggests that to increase households’ clean cooking, identifying inefficiencies that increase the fuel cost and/or providing financial assistance to reduce the burden from fuel price will be crucial.

Figure 54. Primary Stoves, by stacked stoves of two-stove households (nationwide)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## Access to Modern Energy Cooking Based on the MTF

In the analysis with the MTF, access to clean cooking of Rwandan households is measured with four attributes in Figure 55. The lowest tier among the four becomes the households’ final tier classification, or the aggregate cooking Tier. If households score Tier 2 or higher in all cooking attributes, the household’s final tier will also be Tier 2 or above. Falling into the tier range indicates that households have access to clean cooking services (aggregate Tier 4 and 5) or at least improved cooking services in transition to clean cooking (aggregate Tier 2 and 3). Households falling into Tier 0 and 1 are not considered to have access to clean cooking services since their health and safety are critically threatened by cooking activities.

Figure 55. The Multi-Tier Framework Cooking Tier Matrix for Rwanda Survey Analysis

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Attributes** | | **Tier Score** | | | | | |
| Tier 0 | Tier 1 | Tier 2 | Tier 3 | Tier 4 | Tier 5 |
| Exposure | Emission  (*Tier based on stove type*) | Tier 0 | Tier 1 | Tier 2 | Tier 3 | Tier 4 | Tier 5 |
| Ventilation  (*Tier based on ventilation structures in the cooking area*) | 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 |
| Safety (*Harm from stove*) | | Death | - | Serious | Minor |  | None |
| Availability (*Fuel availability*) | | - | | Rarely | Sometimes | Mostly | Always |
| Note: Each attribute has a different Tier score range. Gray sections in the table means they are not in the score range. | | | | | | | |
| *Source: Bhatia and Angelou 2015* | | | | | | | |

**Aggregate Cooking Tier**

As of 2022, the majority of Rwandan households do not have access to clean cooking. Nationwide 92% of households fall into aggregate cooking Tier 0 and 1, which suggests that many Rwandan households are exposed to threats from unhealthy cooking practices (Figure 56).[[10]](#footnote-10) Rural areas where three-stones/open fire stoves and traditional stoves burning firewood are widespread have a higher proportion of households without clean cooking access compared to urban areas. In rural areas, 97% of households do not have clean cooking access classified as Tier 0 and 1, while the proportion is 28 percentage points lower in urban areas (Figure 56). Although urban areas have better access to clean cooking with a higher proportion of households with aggregate cooking Tier 5 compared to rural areas, overall clean cooking access is low in both localities, and this emphasizes the need of advertising healthy cooking practices and expanding improved cookstove options for households across the country.

Figure 56. Household Distribution Based on the Aggregate Cooking Tier, by locality (2022)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

**Cooking Exposure**

The Exposure attribute captures health impacts of cooking activities based on cookstove emissions and ventilation of cooking areas. Households cooking indoors with high emission stoves such as three-stones/open fire stoves and traditional biomass stoves without a good ventilation are placed in low Tiers of the attribute.

Many Rwandan households are still exposed to a high pollutant cooking environment threatening their health in 2022. Compared to 2016, nationwide the distribution of households across Exposure Tiers did not improve considerably over time though Tier 5 households slightly increased (Figure 57). The share of Tier 0 households increased instead during the time frame. Tier 0 households heavily adopt three/stone open fire stoves and traditional stoves (Figure 58), and most of them do not own a ventilation system like chimneys or hoods, which would have led them to score low Tiers of the attribute (Figure 59).

Figure 57. Nationwide Household Distribution Based on the Exposure Tier (2016 vs 2022)

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 58. Households’ Primary Stoves, by Exposure Tier (2022)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 59. Households in Exposure Tier 0 and 1 without Any Ventilation Systems

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

By locality, the cooking environment has improved in urban areas. As Figure 60 shows, while rural household distribution across Exposure Tiers did not improve from 2016 to 2022, in urban areas, the proportion of Tier 5 households increased by 19.4 percentage points. Most households in Tier 5 adopt LPG stoves (Figure 58), and the rise in LPG stove adoption in urban areas as Figure 46 described would have increased the share of Tier 5 households in urban areas.

Figure 60. Household Distribution Based on the Exposure Tier, by locality (2016 vs 2022)

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

**Convenience**

This attribute assesses convenience of households’ cooking activities based on time spent on fuel preparation including fuel acquisition and stove preparation. For many Rwandan households, fuel and stove preparations are time-consuming activities. A high proportion of Rwandan households spend seven hours or more per week on fuel acquisition and preparation, especially in rural areas (Figure 61). Rural households' high reliance on three-stones/open fire stoves and traditional stoves that use collected wood as the fuel would explain the concentrated share of the households in Tier 1 of the Convenience attribute. Compared to rural areas, cooking convenience is better in urban areas with a higher proportion of households classified above Tier 1. Urban households’ lower dependence on collected wood-based stoves and a higher use of LPG stoves likely drive their comparatively higher Convenience Tiers.

Figure 61. Household Distribution Based on the Convenience Tier, by locality (2022)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| \* Convenience Tier Cheat Sheet: | | | | | | | |
|  | | 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**

The attribute captures fuel availability of households using three-stones/open fire stoves and traditional/locally built stoves in the past 12 months of the survey period. Fuel availability is more of an issue for rural households whose use of firewood is high. As shown in Figure 62, 33.8% of rural households find their fuel rarely or sometimes available, while the share is 13.7% in urban areas. Compared to 2016, fuel availability was negligibly improved by 2022 (Figure 62 and Figure 63).

Figure 62. Household Distribution Based on the Availability Tier, by locality (2022)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 63. Household Distribution Based on the Availability Tier, by locality (2016)

*Sources: Koo et al. 2018*

**Safety**

The Safety attribute evaluates how safe the main cookstove is based on the record of any harm or injury in the past 12 months. In 2022, cookstoves are generally safe in Rwanda. Nationwide, most households fall into Tier 5 of the attribute (Figure 64). Cooking safety did not greatly change from 2016 to 2022.

Figure 64. Household Distribution Based on the Cooking Safety Tier, by locality (2016 vs 2022)

*Sources: Koo et al. 2018; “Multi-Tier Framework Survey in Rwanda” 2022*

## Improving Access to Modern Energy Cooking

Expanding Use of Improved Biomass Stoves

To expand clean cooking practices in Rwanda, improved biomass stoves could be offered as a clean cooking option, but households’ low affordability and lack of awareness of the need could be barriers for the transition. In the survey, households currently using either three-stones/open fire stoves or traditional biomass stoves were asked if they are willing to pay for an improved firewood cookstove with higher fuel efficiency and less emissions at different price points. As Figure 65 shows, 83.8% of households were willing to pay for an improved firewood cookstove at 2500 RWF (~2.4 USD), either in full or installments. Additionally, 73.6% showed willingness to purchase a firewood stove at 7500 RWF (~7.3 USD).

For households never willing to accept improved cookstove offers, affordability is the challenge. More than three fourth of households not willing to pay for improved stoves reported that they cannot afford the cookstove payment (Figure 66). 16% of households reported that they are not willing to take the improved stove offer because they do not need one. To increase clean cooking practices in Rwanda, relieving cost burden from transitioning to improved stoves and implementing awareness campaigns of clean cooking practices would be important.

Figure 65. Willingness to Pay for an Improved Firewood Cookstove (nationwide)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 66. Why Households Are Never Willing to Pay for an Improved Stove (nationwide)

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

LPG Stove as a Clean Cooking Option, But High Fuel Cost As a Barrier

LPG stoves could be a clean cooking option for Rwandan households especially in urban areas with high LPG availability, but the high fuel cost would be the challenge. In the survey, each sampled village had 18 households, and if a village has at least one household using LPG stoves, the village was considered to have access to LPG stoves. Based on the assumption, the survey shows that a high share of urban villages of 79.3% have LPG stove access, while in rural areas, 8.5% of villages have LPG stove availability (Figure 67). In urban villages with the stove availability, 31.4% of households use the LPG stove as their primary method of cooking (Figure 68). On the other hand, in rural areas with access to LPG stoves, 11% of households use the LPG stoves. To improve households’ clean cooking practices, promoting use of LPG stoves could be effective especially in urban areas with higher LPG uptake rate.

However, the barrier for LPG stove expansion would be the high fuel cost. As previously mentioned in the Stove Stacking section, all households owning LPG stoves but keeping them aside reported that the fuel is too expensive. To expand LPG stoves, financial means to relieve the cost burden from the fuel will be crucial.

Figure 67. Sampled Villages with LPG Availability

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 68. LPG Stove Uptake, by locality

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

# POLICY RECOMMENDATIONS

**Promote research and development of efficient and affordable clean cooking solutions.**

The survey shows that nationwide the highest share of 67.2% of Rwandan households cooks with either three-stones/open fire stoves or traditional/locally built stoves still in 2022. To transition to a better performing stove, LPG stoves could hardly be an option for many of the households since availability of LPG stoves is mainly limited to urban areas, and the fuel cost is high. Instead, affordable, efficient cooking options should be available to households. Working with local experts and manufacturers, research and development of affordable clean cooking solutions should be initiated.

**Launch awareness campaigns to encourage clean cooking practice.**

The measurement of access to clean cooking based on the MTF shows that 92% of households are placed in Tier 0 and 1 for their final cooking tier classification, which shows that many Rwandan households are still exposed to threats from unhealthy cooking practices. Campaigns to advertise and educate clean cooking practices, their health impact and cost-effectiveness should be initiated and stimulate the demand for improved cookstoves. Since the use of clean cooking methods is negligible in provinces other than Kigali City, promoting campaigns in the lagging regions is crucial.

# GENDER ANALYSIS

# RWANDA OVERVIEW BY GENDER

In Rwanda, male household heads are more common than female heads. As Figure 69 shows, 75.4% of households have male-heads, and 24.6% are led by female-heads. The ratio does not show substantial differences across localities; in urban areas, households led by female heads account for 27.2%, while in rural areas, the share is 24.1%.

Figure 69. Nationwide Distribution of Households, by sex of household head

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Among female-headed households, the share of socio-economically vulnerable households is higher than of male-headed households. Female-headed households show a larger proportion of Ubudehe Category 1 than male-headed households by about three times (Figure 70).

Figure 70. Household Distribution Based on Ubudehe Categorization, by sex of household head

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Male household heads are more likely to be educated and employed than female heads. While 75.7% of male households ever attended schools, the share is lower by 25.2 percentage points among female heads (Figure 71). Also, more than half of male heads were employed in the past seven days of the survey period, but the rate of employment of female heads was 27.1 percentage points lower.[[11]](#footnote-11)

Figure 71. Education and Employment of Household Heads, by sex of household head

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Male heads are more likely to be married compared to female heads. 93.3% of male heads were in marriage with or without a legal certificate, but the married proportion among female heads was just 22.2% (Figure 72). Female heads tend to take the headship when they do not have a spouse. 58.6% of female heads were widows, 9.4% were single, and 7% were separated, while the proportions of the separated marital status among male heads are small.

Figure 72. Marital Status of Household Head, by sex

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## **Electricity Access**

Compared to 2016, electricity access of households led by both female and male heads similarly improved by 2022, but female-headed households show lower access than male-headed households. 55.9% of female-headed households have access to at least one electricity source, which is about 11 percentage points lower than the share of male-headed households with access (Figure 73). The difference is mainly driven from the grid rate. Of female-headed households, 43.5% rely on the national grid as their primary electricity source, while the rate is higher by 10 percentage points for male-headed households. Access to off-grid solutions do not show much difference between the headships, and for both, solar lighting systems are the commonly used off-grid technology (Figure 74).

Figure 73. Access to Electricity Technologies, by sex of household head

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 74. Access to Electricity Technologies, by sex of household head

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## **Access to Modern Energy Cooking Services**

Households do not show major differences in their clean stove use by the sex of the household head. In Rwanda, the proportion of male-headed households using LPG stoves and electric stoves show only negligible difference from female-headed households (Figure 75). Both male-headed households and female-headed households highly adopt three-stones/open fire stoves and traditional biomass stoves though the use of three-stones/open fire stoves is slightly higher among female-headed households.

If LPG stoves are available, male-headed households are more likely to adopt them than female-headed households. In villages where LPG stoves are available, nationwide 27.3% of male-headed households use LPG stoves, while the proportion is 9.4 percentage points lower for households with female heads (Figure 76). The higher LPG stove uptake by male-headed households could be explained by their larger share of higher Ubudehe categories which show higher adoption of more advanced cooking solutions (Figure 48 and Figure 70).

Figure 75. Primary Cookstove, by sex of household head

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 76. LPG Uptake, by sex of household head

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

In Rwanda, female household heads cook more often for their families compared to male heads. As shown in Figure 77, 75.2% of female heads cook every day for their households, while the proportion is only 6.6% among male heads. 70.7% of male heads reported they never cook.

In accordance with the above, female household members spend more time on cooking and cooking preparation than male members do. On a typical day, female members spend on average an hour and a half on fuel and stove preparations along with cooking, while male members spend only 17 minutes. The higher presence of female household members in cooking activities suggests that improvements in the cooking environment will mainly benefit them.

Figure 77. Frequency of Cooking, by sex of household head

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

# 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 fuels and spend more time in the cooking space, so they would benefit most from switching to an improved stove. Cookstove-related promotion campaigns and dissemination efforts should be adequately tailored to both a male and female audience taking the contextual situations of urban and rural settings into consideration.

# REFUGEE HOUSEHOLD ANALYSIS

## Rwanda Refugee Context

Rwanda has been hosting refugees over two decades since the arrival of Congolese refugees at the start of civil war in the Democratic Republic of Congo (DRC) in 1996 (UNHCR The UN Refugee Agency 2021). Today, Rwanda continues providing refugee protections in coordination with UNHCR (Ministry in charge of Emergency Management (MINEMA), n.d.), and as of the end of March 2023, 126,429 refugees, predominantly from the DRC and Burundi, are registered in the five refugee settlements of Rwanda: Kigeme, Kiziba, Mahama, Mugombwa and Nyabiheke camps (Map 2).

Map 2. Refugee Settlements of Rwanda

지도이(가) 표시된 사진

자동 생성된 설명

*Source: "Rwanda Population of Concern to UNHCR" 2023*

*Refugee Integration Policies in Rwanda*

The Government of Rwanda (GoR) has actively implemented policies for refugee protection and inclusion in Rwandan society. In 2016, the GoR announced four commitments on refugee inclusion in the national system at the Leader's Summit for Refugees in New York: graduating camp-based refugees out of assistance programs and increasing formal access to work opportunities, providing all refugees with ID cards, integrating refugee children into national education systems and granting urban refugees access to national health insurance systems (Ministry in charge of Emergency Management (MINEMA), n.d.). In 2018, Rwanda signed on to roll-out the Comprehensive Refugee Response Framework, which provides for a more comprehensive, predictable and sustainable response that benefits both refugees and the host community (UNHCR The UN Refugee Agency Rwanda 2018). To ensure a better quality standard of living for refugees and host communities, in February 2019, the GoR established the Strategic Plan for the Inclusion of Refugees (2019-2024) that assesses the baseline status in achieving the four commitments from 2016, identifies challenges, strategic objectives, and sets prioritized activities, a financial strategy and a monitoring framework (The Global Compact on Refugees, n.d.).

During the Global Refugee Forum in December 2019, the four commitments were renewed, and the areas of refugee integration were extended to 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 The UN Refugee Agency 2020; Ministry in charge of Emergency Management (MINEMA) 2022). In 2021, the Rwanda Ministry in charge of Emergency Management (MINEMA) jointly with UNHCR developed the Economic Inclusion Strategy (2021-2024) that aims at graduating refugees out of poverty (The Global Compact on Refugees, n.d.). Today, the MINEMA works closely with government branches and UNHCR towards fulfilling the commitments and objectives (The Global Compact on Refugees, n.d.).

*Energy Access in Refugee Camps*

Access to electricity and clean cooking has been promoted for refugee households in recent years. Solar street lights have been installed in refugee locations by UNHCR since 2017 (United Nations High Commissioner for Refugees (UNHCR) 2022), and households’ access to electricity from solar home systems[[12]](#footnote-12) increased in Gihembe[[13]](#footnote-13), Kigeme, and Nyabiheke camps through the solar market system development[[14]](#footnote-14) of the Renewable Energy for Refugees (RE4R) project led by Practical Action, a global charity, and UNHCR from April 2017 to February 2022 (Practical Action, n.d.).

Clean cooking access of refugee households has been increased by UNHCR’s distribution of LPG cylinders, fillings and cookers to households in the largest refugee camps of Mahama and Mugombwa responding to firewood ban by the GoR in 2018 (United Nations High Commissioner for Refugees (UNHCR) 2022). Also, many refugee and host community households transitioned to an improved cooking solution between 2019 and 2021 with the support from UNHCR (United Nations High Commissioner for Refugees (UNHCR) 2022). As of mid-2022, the survey shows that 38.3% of refugee households across the five camps have at least one source of electricity, and 62.1% of refugee households have access to LPG cooking.

## Access to Electricity

## **Electricity Access by Technology**

Across all five refugee settlements in Rwanda, 38.3% of households have access to at least one electricity source, which is 19.1 percentage points lower than the access of households in host communities (Figure 78). While many households in host communities have access to the national grid, refugee households predominantly rely on off-grid technologies, more specifically solar lanterns and other solar lighting systems (Figure 79).

Figure 78. Electricity Access of Refugee Households

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 79. Distribution of Off-grid Technologies, by type of household

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

By camp, Mugombwa and Kigeme are particularly low in their electricity access than the other camps (Figure 80). Camps other than Kiziba and Nyabiheke show a major gap in their electricity access compared to their host communities, which is mainly driven from grid access only available to host communities. In Nyabiheke, SLSs are the most used than in any other settlements, and Mahama shows the highest use of solar lanterns (Figure 81).

Figure 80. Electricity Access of Hosting Communities and Refugee Settlements

\* Note: Names of districts are in the parentheses following the names of refugee camps. Graphs are ordered by the year of the camp establishment in ascending order: Kiziba, the oldest, to Mugombwa, the newest.

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 81. Use of Off-grid Technologies, by refugee camp

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## **Electricity Access Measurement with the Multi-Tier Framework**

Although 38.3% of refugee households have at least one electricity source as shown in Figure 78, the MTF measurement of electricity access shows that across refugee camps, only about 15% of refugee households are classified as aggregate Tier 1 or above (Figure 82). The rest of refugee households fall into Tier 0 from either not having any electricity source or hardly having electricity due to its poor capacity and/or low availability. 23.7% of the refugee population fall into Tier 0 despite their connection to solar technologies.

Figure 82. Distribution of Refugee Households based on Aggregate Electricity Tier

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

The analysis of Availability attribute shows that of refugee households with at least one source of electricity, more than half of refugee households live with less than eight hours of electricity per day (Figure 83). About one out of five refugee households have less than four hours of electricity during the whole day.

Figure 83. Refugee Household Distribution based on the Day Availability Tier

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## **Electrical Appliance Use**

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 84).

Figure 84. Appliance Use of Refugee Households

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## **Use of Off-grid Solar Technologies**

Most refugee households depend on just one solar device for electricity (Figure 85). The survey shows that many refugee households using solar lanterns obtained their devices for free, and among those who paid for their lanterns, a high share of households made a lump-sum payment upfront (Figure 86). Of refugee households using SLSs, the highest proportion paid for their solar system in installments at upfront.

Figure 85. Number of Solar Devices

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 86. Upfront Payment for the Main Solar Device

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

As the most serious problem of the main solar device, short duration of service and not being able to power large appliances are the most reported by refugee households using solar lanterns and SLSs, respectively (Figure 87). Among refugee households relying on solar lanterns, about 20% reported that their solar devices break down too often. Of households using SLSs, almost 10% reported the same issue, and roughly 6% found battery problems to be the most serious problem.

Figure 87. Most Serious Problems with the Main Solar Device

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## Access to Clean Cooking

Many refugee households have access to clean stoves, more specifically LPG stoves. As Figure 88 shows, 62.1% of refugee households use LPG stoves, which is significantly higher than the clean stove adoption of non-refugee households. The high use of LPG cookers among refugee households is likely to be from the UNHCR’s intervention. As Figure 89 shows, Mahama and Mugombwa camps where UNHCR distributed LPG stoves and fuels replacing firewood use show higher use of the clean stove compared to the other camps (United Nations High Commissioner for Refugees (UNHCR) 2022).

Figure 88. Primary Cookstoves of Refugee Households

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 89. Primary Cookstoves of Refugee Households, by camp

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

In line with the high use of LPG stoves, LPG is the most used cooking fuel by refugee households across all camps (Figure 90). More than one out of 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 91).

Figure 90. Cooking Fuel Use of Refugee Households

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

Figure 91. Refugee Households' Cooking Fuel, by stove

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

## Policy Recommendations

**Expand electricity access in refugee settlements.**

The survey shows that refugee settlements overall have low electricity access. Only 38.3% of refugee households have access to electricity sources, and the share of households with Tier 1 level access or above accounts for only about 15% of refugee households. Across all settlements, electricity access should be improved.

For electrification of refugee settlements, penetration of off-grid solar technologies could be increased. The survey shows that off-grid solar technologies are already the most widespread sources of electricity in refugee settlements, and many refugee households were willing to purchase their solar devices. For refugee households’ electricity access through solar technologies to be sustainable, ensuring product quality and developing easy access for maintenance should be entailed.

**Initiate awareness campaigns and expand options for clean cooking.**

While the camps with UNHCR’s interventions have access to LPG stoves, many refugee households in the other settlements rely on high-emission biomass stoves. Targeting these households, campaigns to advertise clean cooking practices and their benefits should be launched. Access to affordable and fuel-efficient cookstoves should be expanded.

# ANNEX

**Annex 1. Household Distribution Based on the Ubudehe Categorization, by locality**

*Source: “Multi-Tier Framework Survey in Rwanda” 2022*

**Annex 2. MTF Electricity Tier Matrix for Public Institutions Surveys**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Attributes** | | **Tier Score** | | | | | |
| Tier 0 | Tier 1 | Tier 2 | Tier 3 | Tier 4 | Tier 5 |
| Capacity | Appliance Capacity | - | ≥ 3W & < 50W | ≥ 50W & < 200W | ≥ 200W  & < 800W | ≥800W | - |
| Main Electricity Source | - | Off-grid solar, generator | Off-grid solar, generator | Off-grid solar, generator | Off-grid solar, generator | National Grid or Mini Grid |
| 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  (≤ 3 disruptions &  ≥ 2 hrs duration) | (Disruptions ≤ 3)  AND  (duration < 2 hrs) |
| Quality | | - | | | With voltage issues | - | No voltage issues |
| Formality | | - | | | Informal | - | Formal |
| Safety | | - | | | Had past accidents | - | Safe, no accidents |
| Note: Each attribute has a different Tier score range. Gray sections in the table means they are not in the score range. | | | | | | | |
| *Source: Bhatia and Angelou 2015* | | | | | | | |

**Annex 3. Rwanda Electricity End-user Tariffs for Residential Customers**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **2016** | |  | **2022** | |
| Customer Category | Tariff |  | Consumption Block | Tariff (VAT and regulatory fee Exclusive) |
| Low Voltage –  All (Residential and Non-Residential) | 182 RWF/kWh | <15 kWh per month | 89 RWF/kWh |
| 15-50 kWh per month | 212 RWF/kWh |
| >50 kWh per month | 249 RWF/kWh |

*Source: Rwanda Utilities Regulatory Authority (RURA) 2015;* *Rwanda Utilities Regulatory Authority (RURA) 2020*

**Annex 4. Solar Products Offered for Willingness-to-pay Module**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Tier | Product | Price  (RWF) | Subsidy Level | Subsidy amount (RWF) | Current  Max  Subsidy  Amount  (RWF) | WTP  Price  Points (RWF) |
| Tier 1 | * Company: Lemi * Model: LM-LI020 * Characteristics: With 3 Lamps,   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 * Characteristic: With 4 Lamps, 1 Portable light, 24’’ TV, Radio, 24 Months warranty | 350,000 | - | 135,000 | 100,000 | 215,000 |
|  | - | 105,000 | 80,000 | 245,000 |
|  | - | 67,500 | 50,000 | 282,500 |

*Source:*

**Annex 5. Improved Cookstoves Offered for Willingness-to-pay Module**

|  |  |  |
| --- | --- | --- |
| Type of Stove | Product | WTP Price Points (RWF) |
| Firewood | Songa  (easy to operate, fuel efficient, less smoke) | Two Price Points:   * 2,500 RWF * 7,500 RWF |
| Charcoal | Ecozoom Jiko bora mama yao  (easy to operate, fuel efficient, less smoke) | Two Price Points:   * 16,000 RWF * 21,000 RWF |
| LPG | Realflame Elite (clean, fast) | Three Price Points:   * 8,200 RWF * 24,600 RWF * 45,100 RWF |
| *Source: (CESS Ltd, 2022b)* | | |

**Annex 6. Rwanda Cookstove Typology**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Three-stones Stove** | | | | |
| **Stove Type** | | **Picture** | **Fuel** | |
| Three-stones | |  | Firewood | |
| **Traditional/Locally Built Stoves** | | | | |
| **Stove Type** | | **Picture** | **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** | **Picture** | | | **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 |  | | | Briquette-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** | **Picture** | **Fuel** |
| All LPG stoves |  | LPG |
| **Electric Stove** | | |
| **Stove Type** | **Picture** | **Fuel** |
| All Electric stoves |  | Electricity |
| *Source: CESS Ltd, 2022b* | | |

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1. The MTF access rate includes access provided by off-grid technologies, which is often excluded by the binary rate, but excludes grid connections that do not meet the MTF criteria for a minimum level of service. [↑](#footnote-ref-1)
2. Households’ MTF Capacity tier is based on their appliance tier and the main source of electricity. While a household’s appliance tier is the major determinant of its allocation in the MTF ranking, there is not a one-to-one correspondence, since the source of electricity plays a role, too. Please note that grid-connected households are automatically assigned to Tier 5 for Capacity attribute regardless of their appliance ownership, so Capacity is discussed for off-grid households only. [↑](#footnote-ref-2)
3. Note that the definition of solar home systems (SHSs) in the analysis of this report is different from how the Ministry of Infrastructure of Rwanda defines. The Ministry defines SHSs to be off-grid solar photovoltaic systems that include multiple, two or more, light points (Republic of Rwanda Ministry of Infrastructure 2022). However, based on the definition in this report, solar devices that could power two or more light bulbs could either be solar lighting systems (SLSs) or SHSs depending on the ability to power electrical appliances other than radio and/or phone charging as described in Box 2. [↑](#footnote-ref-3)
4. Household air pollution has been associated with a wide range of adverse health impacts, such as increasing risk of acute lower respiratory infections among children ages under 5 and chronic obstructive pulmonary disease and lung cancer (in relation to coal use) among adults ages more than 30. An association between household air pollution and adverse pregnancy outcomes (such as low birthweight), ischemic heart disease, interstitial lung disease, and nasopharyngeal and laryngeal cancers may also be tentatively drawn based on limited studies (Dherani et al. 2008; Rehfuess, Mehta, and Prüss-Üstün 2006; Smith, Mehta, and Maeusezahl-Feuz 2004). [↑](#footnote-ref-4)
5. This is based on households’ primary electricity source. The options for main electricity sources in the survey were: the national grid, off-grid technologies (mini-grid, electric generator, solar lantern, other solar lighting systems, solar home system and rechargeable battery), dry-cell battery or no electricity. Households that reported dry-cell batteries for their main electricity source were not considered to have electricity along with those who chose no electricity option. [↑](#footnote-ref-5)
6. Off-grid technologies in the MTF survey include mini-grids, electric generators, solar lanterns, other solar lighting systems, solar home systems and rechargeable batteries. Note that no Rwandan households adopt electric generators as their primary electricity source based on the survey result. [↑](#footnote-ref-6)
7. This is based on the same assumption for Figure 33. If at least one of 18 households in a sampled village has access to the national grid, the village is considered to have grid availability. [↑](#footnote-ref-7)
8. The survey did not specify the recurrent costs. [↑](#footnote-ref-8)
9. In the survey, the answer options for households' primary stove were: three-stones/open fire stove, traditional/locally built stove, manufactured biomass stove, kerosene stove, LPG stove, electric stove, solar cooker, or any others. The survey showed that no Rwandan households use solar cookers. [↑](#footnote-ref-9)
10. The aggregate cooking Tier distribution in 2022 is not compared with that in 2016 because the types of cooking attributes counted toward the final tier classification were different. [↑](#footnote-ref-10)
11. 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. [↑](#footnote-ref-11)
12. Note that the definition of solar home system in the RE4R project is based on the component of the solar system (Practical Action 2021), which is different from how SHS is defined in this report based on the service level (Box 1). [↑](#footnote-ref-12)
13. Refugees in Gihembe camp were relocated to Mahama camp by December 2021 due to environmental hazards caused by erosion and ravaging ravines, with aging infrastructures (Ministry in charge of Emergency Management (MINEMA) 2021). [↑](#footnote-ref-13)
14. The market-based approach included facilitating private sector companies to adapt business models for refugee markets and global advocacy, strengthening and supporting markets, promoting economic activity for refugees and host communities (Practical Action, n.d.) [↑](#footnote-ref-14)