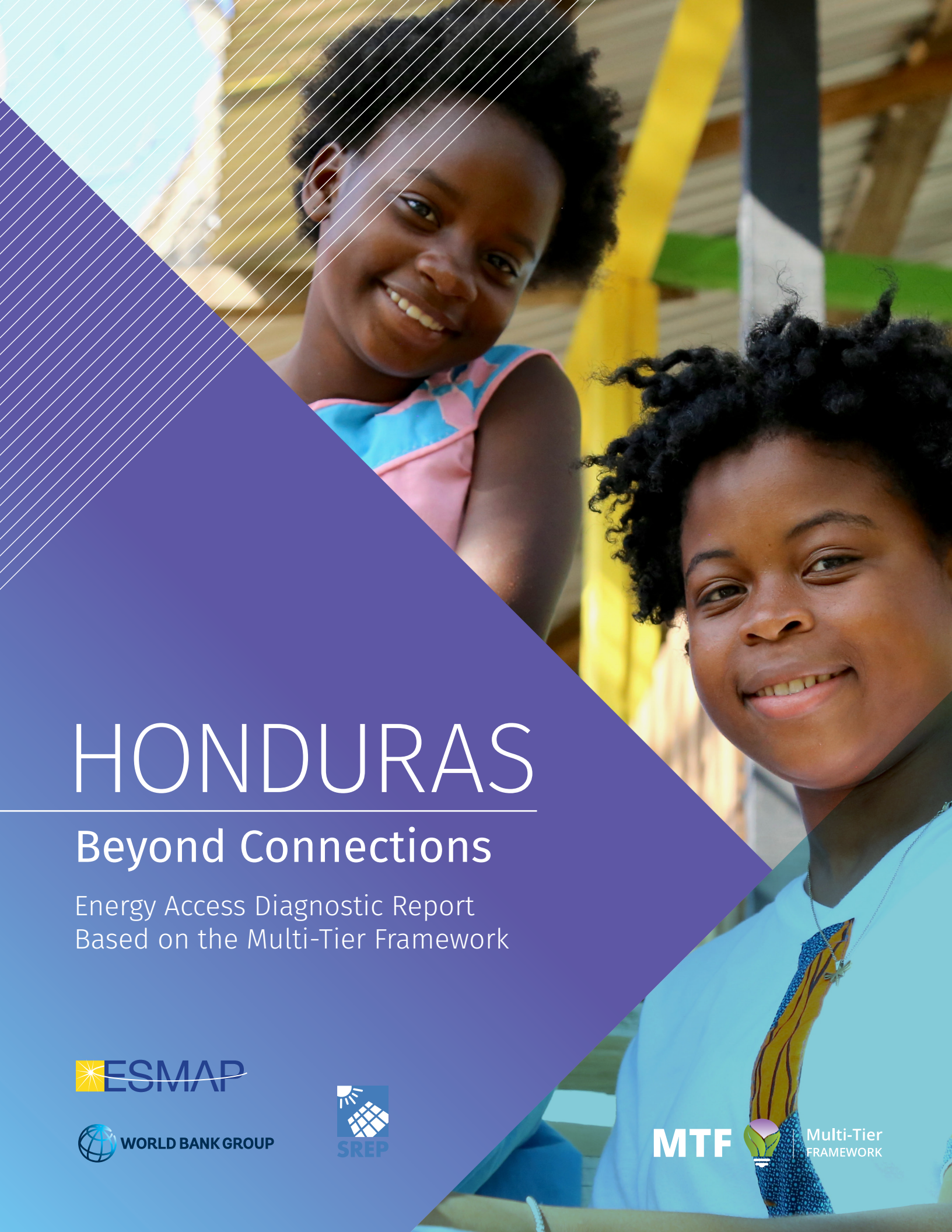


HONDURAS

Beyond Connections

Energy Access Diagnostic Report
Based on the Multi-Tier Framework

ESMAP

WORLD BANK GROUP

SREP

MTF Multi-Tier FRAMEWORK

HONDURAS

Beyond Connections

Energy Access Diagnostic Report Based on the Multi-Tier Framework

Lucia Luzi, Abdul-Farouk Bemba Nabourema, Bryan Bonsuk Koo, Dana Rysankova, Elisa Portale

©2020 International Bank for Reconstruction and Development / The World Bank
1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000

Internet: www.worldbank.org

Publication date: November 2019

This work is a product of the staff of The World Bank with external contributions. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent.

The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Rights and Permissions

The material in this work is subject to copyright. Because The World Bank encourages dissemination of its knowledge, this work may be reproduced, in whole or in part, for noncommercial purposes as long as full attribution to this work is given.

Any queries on rights and licenses, including subsidiary rights, should be addressed to World Bank Publications, The World Bank Group, 1818 H Street NW, Washington, DC 20433, USA; fax: 202-522-2625; e-mail: pubrights@worldbank.org.

Report and Cover design: Lauren Kaley Johnson, GCSPM, The World Bank Group
Text Layout: Duina Reyes
Cover photo: World Bank

CONTENTS

ACKNOWLEDGMENTS vii

ABBREVIATIONS ix

EXECUTIVE SUMMARY x

Access to electricity x

Access to modern energy cooking solutions xi

Gender analysis xii

MEASURING ENERGY ACCESS IN HONDURAS xiv

Multi-Tier Framework Global Survey 2

Access to electricity 3

Access to modern energy cooking solutions 6

Using the Multi-tier Framework to Drive Policy and Investment 8

Multi-Tier Framework survey implementation in Honduras 9

ACCESS TO ELECTRICITY 12

ASSESSING ACCESS TO ELECTRICITY 13

Technologies 13

MTF tiers 14

MTF attributes 17

Use 22

Improving access to electricity 24

Providing electricity access to households without an electricity source 25

Improving electricity access for grid-connected households 26

Improving electricity access for households with off-grid solar solutions 29

Policy recommendations 33

ACCESS TO MODERN ENERGY COOKING SOLUTIONS 34

Assessing access to modern energy cooking solutions 35

Technologies 35

MTF tiers 38

MTF attributes 41

Improving access to modern cooking solutions 45
Increasing penetration of clean fuel stoves 46
Increasing adoption of clean cooking solutions 46
Policy recommendations 47

GENDER ANALYSIS 48
How do households differ by gender of head of household? 49
Access to electricity 52
Access to modern energy cooking solutions 54
Policy recommendations 55

ANNEX 1. MULTI-TIER FRAMEWORKS 57

ANNEX 2. SAMPLING STRATEGY 59
Sample size calculation parameters 59
Sample size calculation 60
Selection of sectors (PSUs) and segments 63
Selection of households 65
Sample weighting calculations 67

ANNEX 3. COOKSTOVE TYPOLOGY 70

REFERENCES 74

BOXES

Box 1 · Minimum Electricity Requirements, by Tier of Electricity Access 5
Box 2 · Typology of Off-Grid Solar Devices and Tier Calculation 6
Box 3 · Typology of Cookstoves in Honduras 8

TABLES

Table 1 · Share of renewable energy consumption in total final energy consumption, 1990–2015 2
Table 2 · Appliances by load level and associated Capacity tiers 6
Table 3 · Distribution of enumeration areas and sampled households, MTF Survey, Honduras 10
Table 4 · Distribution of households by tiers (nationwide, urban/rural) 24
Table A 1.1 · Multi-Tier Framework for Measuring Access to Electricity 57
Table A 1.2 · Multi-Tier Framework for Measuring Access to Modern Energy Cooking Solutions 58
Table B 2.1 ·Rural area, distribution of the MTF sample of sectors for access to the national grid, by department 62
Table B 2.2 · Urban area, distribution of the MTF sample of sectors by domain and access to the national grid, by department 63
Table B 2.3 · Rural area, distribution of segments in selected sample by degree of access to the national grid in 2013, by department 64
Table B 2.4 · Urban area, distribution of segments in selected sample by degree of access to the national grid in 2013, by department 65
Table B 2.5 · Rural area, distribution of households in sample by degree of access to the national grid in 2013, by department 66
Table B 2.6 · Urban area, distribution of households in sample by degree of access to the national grid in 2013, by department 67

FIGURES

Figure 1 · Honduras 1
Figure 2 · Departments of Honduras 1
Figure 3 · Sample distribution, MTF survey, Honduras 11
Figure 4 · MTF aggregate tier by expenditure quintile (nationwide) 13
Figure 5 · Access to electricity by technology (urban/rural) 13
Figure 6 · Access to electricity by technology, by departments 14
Figure 7 · MTF tier distribution, by technology (nationwide) 15
Figure 8 · MTF tier distribution (urban/rural) 15
Figure 9 · Access to electricity by technology, by expenditure quintile (nationwide) 16

Figure 10 · MTF tier distribution by technology, by expenditure quintile (nationwide) 16
Figure 11 · Distribution of households based on electricity Capacity (nationwide, urban/rural) 17
Figure 12 · Distribution of households based on Daily electricity Availability (nationwide, urban/rural) 18
Figure 13 · Distribution of households based on Evening electricity Availability (nationwide, urban/rural) 18
Figure 14 · Distribution of households based on electricity Reliability (nationwide, urban/rural) 19
Figure 15 · Distribution of households based on electricity Quality (nationwide, urban/rural) 19
Figure 16 · Distribution of households based on electricity Affordability (nationwide, urban/rural) 20
Figure 17 · Distribution of households based on Formality (nationwide, urban/rural) 21
Figure 18 · Distribution of households based on Health and Safety (nationwide, urban/rural) 21
Figure 19 · Monthly household average consumption of electricity 22
Figure 20 · Monthly household average expenditure on electricity 22
Figure 21 · Spending on electricity as a share of total household spending 22
Figure 22 · Power level of the appliances used among households (urban/rural) 22
Figure 23 · Appliance power distribution within each aggregate tier by grid and off-grid users (nationwide) 23
Figure 24 · Appliance ownership by grid and off-grid users (nationwide) 23
Figure 25 · Tier 0 disaggregation by source of electricity 24
Figure 26 · Comparison of electrification rate between villages (EA) and households (nationwide, urban/rural) 25
Figure 27 · Barriers to gaining access to grid electricity among households not connected to the grid (urban/rural) 25
Figure 28 · Expenditure quintile distribution for households without electricity (urban/rural) 26
Figure 29 · MTF tier distribution of grid-connected households (urban/rural) 26
Figure 30 · Distribution of grid-connected households based on Quality (nationwide) 27
Figure 31 · Distribution of grid-connected households based on Reliability (nationwide) 27
Figure 32 · Distribution of grid-connected households based on Formality (nationwide) 27
Figure 33 · Main issues cited, related to grid electricity supply (nationwide) 28
Figure 34 · Distribution of grid-connected households by backup energy source for lighting (urban/rural) 28
Figure 35 · Share of household expenditure on backup sources (urban/rural) 29
Figure 36 · MTF tier distribution of off-grid solar households (nationwide) 29
Figure 37 · Number of years using solar solutions (nationwide) 30
Figure 38 · Solar device acquisition modality (nationwide) 30
Figure 39 · Distribution of off-grid solar households based on Capacity (nationwide) 31
Figure 40 · Distribution of off-grid solar households based on Daily Availability (nationwide, urban/rural) 31
Figure 41 · Distribution of off-grid solar households based on Evening Availability (nationwide, urban/rural) 32
Figure 42 · Satisfaction levels of solar device users (nationwide) 32
Figure 43 · Main issues for households using solar solutions (nationwide) 33

Figure 44 · Distribution of primary cookstove used (nationwide, urban/rural) 35
Figure 45 · Type of fuel usage by sector (nationwide, urban/rural) 36
Figure 46 · Distribution of cookstoves and fuel used (nationwide) 36
Figure 47 · Distribution of cookstoves and fuel used (urban/rural) 37
Figure 48 · Two-stove type users (urban/rural) 38
Figure 49 · MTF tier distribution: access to modern energy cooking solutions (nationwide, urban/rural) 39
Figure 50 · MTF tier distribution by primary stove type (nationwide) 39
Figure 51 · MTF tier distribution by primary stove type (urban/rural) 40
Figure 52 · Distribution of households based on Cooking Exposure (nationwide, urban/rural) 41
Figure 53 · Distribution of households based on total Convenience (nationwide, urban/rural) 42
Figure 54 · Distribution of households based on fuel Convenience (time spent for fuel collection and preparation, nationwide, urban/rural) 42
Figure 55 · Distribution of households based on stove Convenience (time spent for stove preparation), (nationwide, urban/rural) 43
Figure 56 · Distribution of households based on Safety of Primary Cookstove (nationwide, urban/rural) 43
Figure 57 · Distribution of households based on Fuel Availability (nationwide, urban/rural) 44
Figure 58 · Distribution of households based on Affordability (nationwide, urban/rural) 45
Figure 60 · Distribution of households by gender of household head (nationwide, urban/rural) 49
Figure 61 · Marital status of household head, by gender of household head (nationwide) 50
Figure 62 · Education level by gender of household head (nationwide, urban/rural) 50
Figure 63 · Distribution of households by expenditure quintile, by gender of household head (nationwide) 51
Figure 64 · Access to finance (loan/credit) by gender of household head (nationwide, urban/rural) 51
Figure 65 · Access to electricity by technology, by gender of household head (nationwide, urban/rural) 52
Figure 66 · MTF electricity tier distribution, by gender of household head (nationwide, urban/rural) 53
Figure 67 · Barriers to gaining access to the electricity grid (nationwide) 53
Figure 68 · Access to cooking solutions, by type of primary cookstove, by gender of household head (nationwide, urban/rural) 54
Figure 69 · MTF tier distribution, by gender of household head (nationwide, urban/rural) 54
Figure 70 · Average fuel collection time (minutes/day), by primary stove type, by gender (nationwide) 55
Figure 71 · Average fuel preparation time (minutes/day), by primary stove type, by gender (nationwide) 55
Figure 72 · Average cooking time (minutes/day), by gender (urban/rural) 55

ACKNOWLEDGMENTS

The Multi-Tier Framework (MTF) international initiative would not have been possible without the valued technical and financial support of the Energy Sector Management Assistance Program (ESMAP), which is administered by the World Bank.

ESMAP is a global knowledge and technical assistance program to support low middle-income countries in increasing their knowledge of and institutional capacity to achieve environmentally sustainable energy solutions for both poverty reduction and economic growth. ESMAP is funded by Australia, Austria, Denmark, the European Commission, Finland, France, Germany, Iceland, Italy, Japan, Lithuania, Luxembourg, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, and the Rockefeller Foundation, as well as the World Bank. Financial and technical support from ESMAP for the MTF survey is gratefully acknowledged.

Along with ESMAP's support, the Scaling up Renewable Energy Program (SREP) in Low Income Countries also contributed by financing part of the implementation of the MTF survey and the capacity building efforts in Honduras. SREP empowers transformation in energy-deficient countries by identifying the economic, social, and environmental viability of renewable energy.

This initiative has relied on the critical support of multiple entities and individuals that the MTF team would like to acknowledge.

The main contributors to the realization of the MTF Honduras survey project are the field coordinator, Lucia Luzi (Consultant), and the MTF team members Abdul-Farouk Bemba Nabourema (Consultant), Bryan Bonsuk Koo (Energy Specialist), Sandra Keller (Consultant), Yunhui Lin (Consultant), and Giselle del Carmen (Consultant) for supporting the editing; and the MTF Task Team Leaders Dana Rysankova (Global Lead for energy access) and Elisa Portale (Senior Energy Specialist) for their vital contribution to realizing the project. The continuous support and input from the Living Standards Measurement Study (LSMS) team, in particular Palacios-Lopez (Senior Economist) and Lena Nguyen (Survey Analyst), was also critical to the realization of the MTF's Honduras survey project.

The MTF-ESMAP team would like to thank the Government of Honduras for its enthusiasm and support for this project, particularly Ramon Hernandez Alcerro (Minister Coordinator of the Presidency, Head of the Economic Cabinet and Minister of Finance) and José Antonio Galdames Fuentes (Secretary of State) at Secretariat of Environment and Natural Resources (*Secretaría de Energía, Recursos Naturales, Ambiente y Minas* [SERNA]), all of whom helped guide and give their valuable support to the MTF team throughout the process of the survey preparation. Furthermore, the MTF team would like to acknowledge Rene Soler (Census Coordinator), Enrique Chavez (Deputy Director), Ramón Espinoza (Executive Director), and Horacio Lovo Peralta (Manager of Social and Demographic Statistics) at the National Institute of Statistics (*Instituto Nacional de Estadísticas* [INE]), who provided invaluable feedback on the survey design and sampling strategy. The MTF-ESMAP team would like to thank Maria Elena Quan de Martínez at the National Electric Energy Company (*Empresa Nacional de Energía Eléctrica* [ENEE]), Wilfredo Cerrato (President of the Central Bank of Honduras), and Rocio Tábora (Ministry of Finance). MTF-ESMAP's partnership with ESA Consultores, the private firm that conducted the survey in Honduras, was critical to the successful implementation of this initiative. Finally, the MTF team would like to thank the respondents for taking the time and participating in the survey.

The MTF Team would like to extend its thanks to World Bank Honduras Country Office, including Giorgio Valentini (Country Manager), Mariano Gonzalez Serrano (Senior Energy Specialist), Liliana Do Couto Sousa (Economist), Melisa Gaitan Fanconi (Consultant), Daniel Alvaro Diez (Consultant), Martin H. Ochoa (Senior Operations Officer), and Noris Janeth Salinas Reyes (Program Assistant). Yabei Zhang (Senior Energy Specialist), Caroline Adongo Ochieng (Energy Specialist), Alisha Pinto (Consultant), Inka Ivette Schomer (Operations Officer), Nicolina Angelou (Consultant), Verena Brinkmann (GIZ), and Heather Adair-Rohani and Jessica Lewis (World Health Organization) provided comments for the section on access to modern energy cooking solutions.

The MTF-ESMAP team would like to thank everyone who played an integral part in refining the narrative on findings as found in the MTF Honduras Energy Access Diagnostic Report.

ABBREVIATIONS

EA	Enumeration area
ENEE	National Electric Energy Company
ESMAP	Energy Sector Management Assistance Program
GDP	Gross domestic product
HNL	Honduran Lempira
HH	Household
ICS	Improved cookstove
INE	National Institute of Statistics
kW	kilowatt
kWh	Kilowatt-hour
LED	Light-emitting diode
LPG	Liquefied petroleum gas
MTF	Multi-Tier Framework
MW	Megawatts
PSU	Primary sampling unit
RISE	Regulatory Indicators for Sustainable Energy
SERNA	Secretariat of Environment and Natural Resources
SHS	Solar home system
SLS	Solar lighting system
SREP	Scaling up Renewable Energy Program in Low Income Countries
W	Watt
WTP	Willingness to pay

Average exchange rate, May 1, 2017 and June 30, 2017 was 1 USD = 23.6 HNL.

EXECUTIVE SUMMARY

Honduras is a low middle-income country that faces major challenges. In 2017, the GDP per capita (in current US$) amounted to US$2,480 (World Bank, 2018). Since the 2008–09 global economic crisis, the country has experienced a moderate recovery, driven by public investments, exports, and higher remittances.

The World Bank, with support from the Energy Sector Management Assistance Program (ESMAP), has launched the Global Survey on Energy Access, using the Multi-Tier Framework (MTF) approach. The survey's objective is to provide more nuanced data on energy access, including access to electricity and cooking solutions. The MTF approach goes beyond the traditional binary measurement of energy access—for example, "having or not having" a connection to electricity, "using or not using" clean fuels in cooking—to capture the multidimensional nature of energy access and the range of technologies and sources that can provide energy access, while accounting for the wide differences in user experience.[1] .

ACCESS TO ELECTRICITY

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

- **Source of electricity.** The MTF survey data show that, as of 2017, 88.2% of Honduran households have access to electricity mostly through national grid, while the remaining 11.7% have no access to electricity. Out of the 88.2% with electricity, most (84% of all households) are connected to the national grid, and the remaining 4.2% primarily use off-grid solutions. The difference in access to electricity between urban and rural areas is substantial: most urban households (97.3%) access electricity through the national grid, compared to 69.3% in rural areas, in which 22.5% of households have no access to any kind of electricity source. Yet off-grid solutions (mainly solar) seem to be more prevalent in rural areas (8.2%).

- **MTF aggregate tier for access to electricity.** The MTF defines Tier 1 or above as having access to electricity based on Sustainable Development Goal (SDG) 7.1.1. Nationwide, 86.5% of Honduran households are in Tier 1 or above for electricity access. Specifically, 97.8% of urban households and 74% of rural households are in Tier 1 or above. Grid users are mainly concentrated in Tiers 3 through 5, while users of off-grid solutions are primarily in Tiers 0 through 2.

- **Households in Tier 0.** Nationwide, 13.5% of households are in Tier 0 for access to electricity, and nearly all do not have any source of electricity. For households without any source of electricity, it will be critical to provide either an on-grid connection or an off-grid energy solution. Addressing high connection costs and increasing the presence of grid infrastructure are likely to increase the grid electrification rate. Grid infrastructure is available in 91.4% of the enumeration areas (EAs) in the country; however, only 84% of Honduran households are connected to the grid. The low

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

uptake rate of grid connection opens the possibility to increase grid electrification rate by around 7.4% through connecting households that are "under the grid," that is, directly beneath existing grid infrastructure. The penetration rate for off-grid solutions can also be improved by addressing affordability issues through payment plans.

- **Grid-connected households.** Grid-connected households are mostly in higher tiers: 96.1% are in Tier 3 or above, with about 50% in the highest tier, Tier 5. Poor Quality and Reliability are the main issues preventing grid-connected households from being in the highest tier. Formality is a less of an issue, but it still keeps grid-connected households in Tier 3 from being in the highest tier.

- **Off-grid solutions users.** Households using off-grid solar solutions are in Tiers 0 through 3, and they are mainly constrained by Capacity and Availability issues. Although the use of solar solutions is a relatively recent phenomenon in Honduras, 88% of solar users are satisfied with their current service from solar devices.

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

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

- **Primary cookstove and fuel.** Honduran households reported using six types of cookstoves.[4] Most use a biomass stove (including three-stone stoves, traditional stoves and improved biomass cookstove [ICS]) as their primary means of cooking. Most use either ICSs (29.9%) or traditional stove (27.7%), and 6.5% use three-stone stoves. The penetration of clean fuel stoves used as the primary stove is fairly high (35.9%): 25.7% of the households use liquefied petroleum gas (LPG) stoves and 10.2% use an electric stove. Urban and rural households rely on different cooking technologies, with most urban households using either LPG stoves (42.9%) or electric stoves (18.3%), and most rural households using either ICSs (47.4%) or traditional stoves (38.7%). The penetration of both LPG and electric stoves is limited in rural areas (7.2% and 1.5%, respectively).

- **MTF aggregate tier for access to modern energy cooking solutions.** Most households are concentrated in Tier 1 (55.6%), due to the high share of traditional stoves and ICSs. A higher portion of rural households (71.7%) is in Tier 1 compared to urban households (40.7%). By contrast, more urban households fall in higher tiers for access to modern cooking solutions, mainly because clean fuel stoves are mostly used in urban areas, even though using a clean fuel stove does not automatically categorize these households into higher tiers.

- **The MTF attributes that contribute the most to households being in lower cooking tiers are Cooking Exposure and Convenience.** Both are related to the continued use of biomass cookstoves. Cooking Exposure prevents 39% of the households from reaching higher tiers, while Convenience prevents 50% of households from reaching higher tiers. Therefore, to move households to the next tier, efforts should be concentrated toward improving Cooking Exposure and Convenience. Possible solutions for households in lower tiers, which use mostly biomass stoves, are promoting clean fuel stoves. Possible solutions for those in higher tiers, which use clean stoves only, are to expand the

[3] For descriptions of the MTF and its attributes, see Annex 1.
[4] In this report's analysis, Rocket stove gasifier is included in the ICS figure.

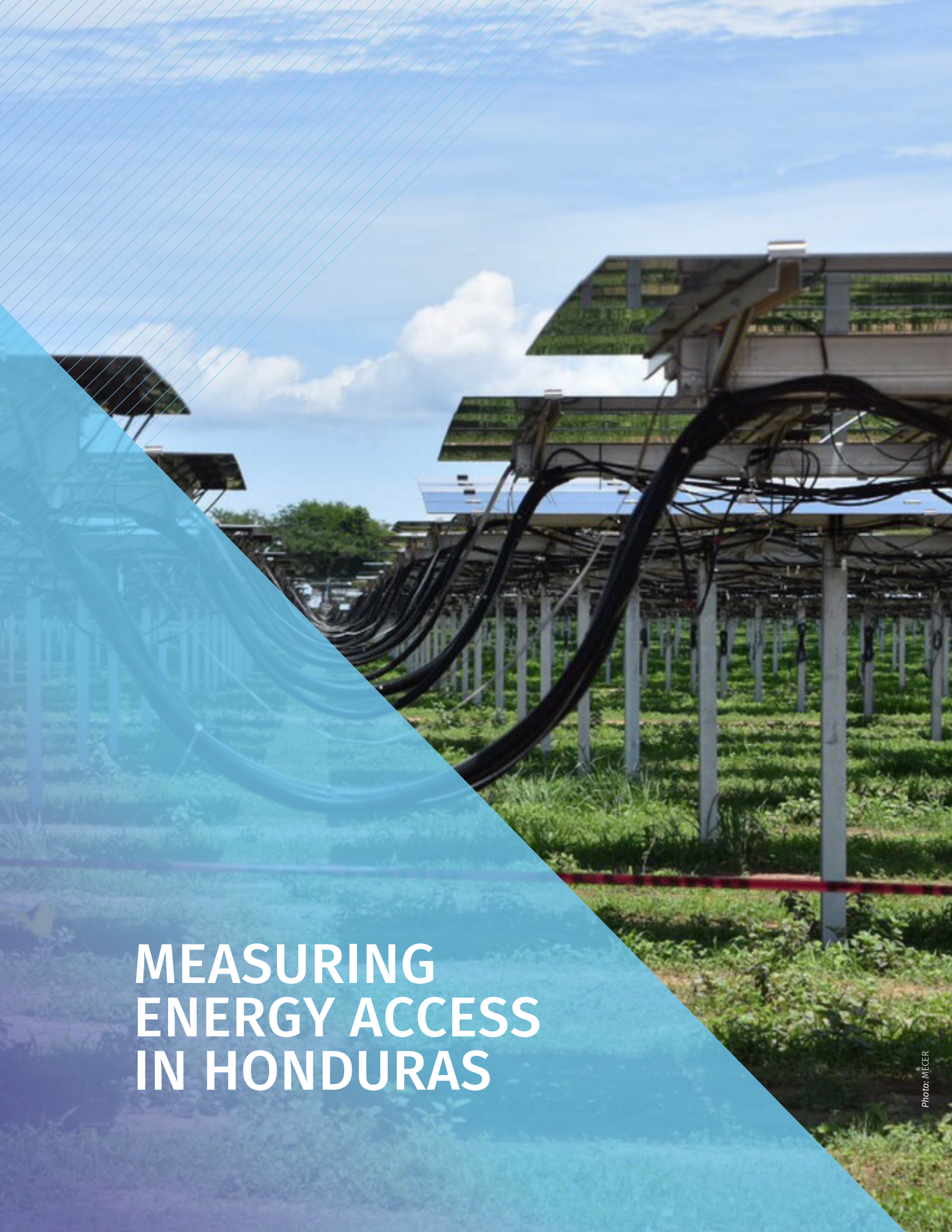
grid infrastructure or LPG network to promote the use of efficient ICSs and to introduce Emission Tier 4 stoves, such as gasifier stoves. More campaigning and sensitization for those households relying on two stoves (for example, one clean fuel and one traditional) are needed to raise the reservation price of the potential users.

GENDER ANALYSIS

Nationwide, 73% of Honduran households are headed by men, and 27% of households are headed by women. Female-headed households account for 32.1% of urban households and 21.2% of rural households. Female household heads are older, live in slightly smaller families, and have a lower average income and level of education than male household heads.

Nationwide, 6.5% of female-headed households and 13.6% of male-headed households have no access to electricity. These female-headed households are more likely to be poorer than male-headed households, because 62.1% of female-headed households without electricity are in the lowest expenditure quintile, compared with about 56% of male-headed households. Female-headed and male-headed households have similar distributions in middle tiers of the MTF aggregate tier for access to electricity, but some variations exist in the lowest and highest tiers. The situation differs between rural and urban areas, but regardless of area, male-headed households are in lower tiers of access compared to female-head households.

Nationwide, in relation to cooking technologies, female-headed households are somewhat more likely to use clean fuel stoves than male-headed households, while there is no gender gap in the use of three-stone or traditional stoves. Women age 15 and older spend a considerably higher amount of time in both fuel preparation and cooking compared to men, girls, and boys. Women are thus much more likely to be affected by indoor air pollution. Hence, cooking solutions may have a larger impact on women compared to the other three groups. Male household members are more responsible for fuel collection, a finding which is divergent from many other country contexts.



MEASURING ENERGY ACCESS IN HONDURAS

Photo: MECER

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 Honduras, 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.

Honduras is a relatively small country, but with a fast-growing economy (Figures 1 and 2). With a population of 9,429 million in 2017, the country spans 111,890 square kilometers, bordering Nicaragua, El Salvador, and Guatemala (World Bank, 2018). For every square kilometer of Honduran land area, there is an average of about 83 people, which makes the country the 127th most densely populated country in the world. More than half of the population (56.5%) is urban (World Bank, 2018), mainly distributed between two large centers, the capital of Tegucigalpa and the city of San Pedro Sula.

Honduras is a low middle-income country that faces major challenges. In 2017, the gross domestic product (GDP) per capita (in current US$) amounted to US$2,480 (World Bank, 2018). Since the 2008–09 global economic crisis, the country has experienced a moderate recovery driven by public investments, exports, and higher remittances. In 2017, the economy grew by 4.8% and by 3.5% in 2018. A 3.6% growth is expected for 2019 (World Bank, 2019).

The economy of Honduras is largely driven by agriculture, which accounted for 13.5% of the GDP in 2016 (World Bank, 2018), but this sector has lost nearly one-third of its revenue over the past two decades, in part due to the declining prices of export crops (World Bank, 2019). Historically, Honduras has relied on its export of bananas and coffee; the country has since diversified its export base to include apparel, textiles, and automobile wire harnessing.

FIGURE 1 • **Honduras**

FIGURE 2 • **Departments of Honduras**

Despite the favorable economic outlook, Honduras faces the highest level of economic inequality in Latin America, and more than 60% of the population were living in poverty in 2018 (World Bank, 2018). In rural areas, approximately one out of five Hondurans live in extreme poverty (less than US$1.90 per day). Honduras ranked 133 of 189 countries on the Human Development Index (HDI) in 2017, with a value of 0.617, which put the country in the medium human development category (UNDP, 2018).

The overall electrification rate in Honduras was 88% in 2016: 100% in urban and 72% in rural areas (IEA et al. 2018). In 2015, electricity losses registered at 33%, which includes technical losses (inherent to the transmission and distribution process) and nontechnical losses (non-billing, electricity theft, and other nontechnical factors) (IEA et al. 2018).

By 2010, Honduras registered an installed capacity of 1,610 MW, of which 36.6% was owned by the National Electric Energy Company (ENEE), and the remaining 63.4% was owned privately. This capacity reached 2,571.3 MW in 2017, with a growth of 5.4% from the previous year. Given that the recent growth in installed capacity has been driven by private initiative, state participation fell to 19.3% of this capacity at the end of 2017 (ENEE, 2017). Internal demand for electricity in the official grid increased from 5,054 GWh in 2010 to 5,552 GWh in 2014, and to 6,176 GWh in 2017 (ENEE, 2017).

The share of renewable energy consumption in total final energy consumption surpassed 50% in 2015, driven by traditional biomass consumption (see Table 1). Only a small fraction of the population has clean cooking fuels. In 2016, 53% of the population had access to clean cooking solutions in 2016 (IEA et al. 2018). The MTF estimates that the portion of households with access to clean cooking solutions in 2017 was about 36%: above 60% in urban and about 9% in rural areas.

TABLE 1 • **Share of renewable energy consumption in total final energy consumption, 1990–2015**

1990	70.13%
2010	53.16%
2014	54.04%
2015	51.54%

Source: IEA et al., 2018.

MULTI-TIER FRAMEWORK GLOBAL SURVEY

The World Bank, with support from the Energy Sector Management Assistance Program (ESMAP), has launched the MTF Global Survey, whose objective is to provide more nuanced data on energy access, including access to electricity and cooking solutions. The first phase is being carried out in 16 countries across Africa, Asia, and Latin America. The MTF approach goes beyond the traditional binary measurement of energy access—for example, "having or not having" a connection to electricity, "using or not using" clean fuels in cooking—to capture the multidimensional nature of energy access and the vast range of technologies and sources that can provide energy access, while accounting for the wide differences in user experience.[5]

[5] 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.

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

ACCESS TO ELECTRICITY

Access to electricity is measured based on seven attributes: Capacity, Availability, Reliability, Quality, Affordability, Formality, and Health and Safety (see Annex 1, Table A.1). The following describes what each of the seven attributes measures.

- ***Capacity*** ("What appliances can I power?"): The capacity of the electricity supply (or peak capacity) is the ability of the system to provide a certain amount of electricity to operate various appliances, ranging from a few watts for light-emitting diode (LED) lights and mobile phone chargers to several thousand watts for space heaters or air conditioners. Appliances are classified into tiers based on their power ratings (see Table 2). 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.[6] Capacity is measured in watts for grids, mini-grid, and fossil fuel generators, and in watt-hours for rechargeable batteries, solar lanterns, solar lighting systems (SLS) and solar home systems (SHS). 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 is considered greater than 2,000 watts) or appliances used (Table 2).

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

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

- ***Quality*** ("Will voltage fluctuations damage my appliances?"): The quality of the electricity supply refers to the absence of severe voltage fluctuations that can damage a household's appliances. Electric appliances generally require a certain level of voltage to operate properly. Low or fluctuating voltage can damage 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 proxy. In this report, Quality attribute is measured for households connected to the grid or a mini-grid.

Affordability ("Can I afford to purchase the minimum amount of electricity?"): The affordability of the electricity service is determined by comparing the price of a standard electricity service package (one kilowatt-hour [kWh] of electricity per day or 365 kWh per year) with household expenditure. The price

[6] 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.

of the package is determined from the prevailing lifeline tariff. If the household spends more than 5% of the household expenditure on electricity, then electricity service is considered unaffordable for that household.

Formality ("Is grid electricity provided through a formal connection?"): If households use the electricity service from the grid, but do not pay anyone for the consumption, their connection is an informal connection. The formality of the grid connection is important, since it ensures that the electricity authority gets 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, thus, infers information on Formality from indirect questions that respondents may be more willing to answer, such as what method a household uses to pay the electricity bill.

Health and Safety ("Is it safe to use my electricity service?"): This attribute refers to any injuries to household members from using electricity service from the grid during the preceding 12 months of the survey. An injury could mean limb injury or even death from burn or electrocution. Such injuries can happen from faulty internal wiring (exposed bare wire, for example) and from incorrect use of electrical appliances or negligence. The MTF analysis, however, does not make a distinction between the two. Electricity access is considered safe when users have not suffered from past accidents or permanent injuries due to their electricity supply.

For each of these attributes, households are placed in a tier depending on the level of service as defined by the different thresholds (see Annex 1, Table A.1). A household's overall tier of access is determined by the lowest tier value the household obtains among the attributes. The distribution of the final aggregated tier and the individual attribute tier for all households as a distribution can be presented at the national level, by locality (urban or rural), and by the sex of the household head (male or female household head).

The lower tiers point to households with no electricity or sources limited by Capacity. The Availability of electricity supply is also a crucial determinant of whether a household is in a lower tier (see Box 1 for minimum requirements by tier of electricity access). Tier 0 refers to households that receive electricity for less than four hours per day (or less than one hour per evening) or that have a primary energy source with a capacity of less than 3 watts (3W). Tier 1 refers to households with limited access to small quantities of electricity provided by any technology, even a small SLS (see Box 2 for a typology of off-grid solar devices), for at least four hours a day, enabling electric lighting and phone charging.

Higher tiers are defined by higher Capacity and longer Availability of supply, enabling the use of medium- and high-load appliances such as refrigerators, washing machines, and air conditioning. The Affordability attribute is applicable for Tiers 3 through 5, while Reliability, Quality, Formality, and Health and Safety attributes are applicable for Tiers 4 and 5. Access to the grid is the most likely result of achieving a higher tier, although a diesel generator or a mini-grid use may result in a similar outcome. Technological advances in photovoltaic solar home systems and direct current–powered energy-efficient appliances can make higher access to Tier 3 and even Tier 4 possible.

BOX 1 • MINIMUM ELECTRICITY REQUIREMENTS, BY TIER OF ELECTRICITY ACCESS

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

Tier 3	Tier 4	Tier 5
At least eight hours of electricity per day are available (including at least three hours per evening), and capacity is sufficient to power medium-load appliances—such as a refrigerator, freezer, food processor, water pump, rice cooker, or air cooler (see Table 2) —as needed during that time. In addition, the household can afford a basic consumption package of 365 kilowatt-hours per year. Sources to meet these requirements include an SHS, a generator, a mini-grid, or the national grid.	At least 16 hours of electricity per day are available (including four hours per evening), and capacity is sufficient to power high-load appliances—such as a washing machine, iron, hair dryer, toaster, or microwave (see Table 2)—as needed during that time. There are no frequent or long unscheduled interruptions, and the supply is safe. The grid connection is legal, and there are no voltage issues. Sources to meet these requirements include diesel-based mini-grids or the national grid.	At least 23 hours of electricity per day are available (including four hours per evening), and capacity is sufficient to power very high-load appliances—such as an air conditioner, space heater, vacuum cleaner, or electric cooker (see Table 2)—as needed during that time. The most likely source for meeting these requirements is a mini-grid or the national grid.

Source: Bhatia and Angelou 2015.

BOX 2 • TYPOLOGY OF OFF-GRID SOLAR DEVICES AND TIER CALCULATION

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

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

Solar lighting systems (SLS) power two or more light bulbs and allow part or the entire household to be classified in Tier 1 for Capacity.

Solar home systems (SHS) power two or more light bulbs and appliances such as televisions, irons, microwaves, or refrigerators. (See Table 2 for the load level associated with each Capacity tier.)

TABLE 2 • Appliances by load level and associated Capacity tiers

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

Source: Bhatia and Angelou, 2015

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

Despite the well-documented benefits of access to clean cookstoves, around three billion of the world's population still use polluting, inefficient cooking fuels and technologies that emit toxic smoke. The inefficient use of solid fuels and the resultant pollution have significant impacts on health, socioeconomic development, gender equality, education, and climate (Ekouevi and Tuntivate 2012; UNDP and WHO 2009).[7] Fuel collection and cooking tasks are often carried out by women and girls; and collection time depends on the local availability of fuel and may take up to several hours per day (ESMAP, 2004; Gwavuya et al. 2012; Parikh 2011; Wang et al. 2013). Time spent in fuel collection

[7] Household air pollution is associated with a wide range of adverse health impacts, including increasing risk of acute lower respiratory infections among children under five years old, and chronic obstructive pulmonary disease and lung cancer (in relation to coal use) among adults above 30 years old. An association between household air pollution and adverse pregnancy outcomes (that is, low birth weight), 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 Pruss-Ustun, 2006; Smith, Mehta, and Maeusezahl-Feuz, 2004).

often translates into lost opportunities for gaining education and increasing income (Blackden and Wodon, 2006; Clancy, Skutch, and Batchelor, 2003). In addition, associated drudgery increases the risk of injury and attack (Rehfuess et al., 2006).

The MTF measures access to modern energy cooking services using six attributes: Cooking Exposure, Cookstove Efficiency, Convenience, Safety of Primary Cookstove, Affordability, and Fuel Availability (see Annex 1, Table A.2).

- ***Cooking Exposure*** ("How is the user's respiratory health affected?"). This attribute assesses the personal exposure to pollutants from cooking activities, which depends on stove emissions and ventilation parameters (including cooking location and kitchen volume).[8] Cooking Exposure is a proxy indicator for the health impacts of the cooking activity on the primary cook. This attribute is a composite measurement of the emissions from the cooking technology and fuel combination, that is, a combination of the stove type and fuel, mitigated by the ventilation in the cooking area. Each component has one or more subcomponents (Annex 3). The Cooking Exposure tier is assigned as a composite of emissions and ventilation tiers and is weighted by the amount of time spent on each stove, if a household relies on multiple stove types.

- ***Cookstove Efficiency*** ("How much fuel will a person need to use?"). This attribute is a combination of combustion efficiency and heat transfer efficiency. Laboratory testing of the efficiency of various types of cookstoves informs the breakdown of efficiency levels by cookstove and fuel combinations, which can be observed in the field with relative ease.[9]

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

- ***Affordability*** ("Can a person afford to pay for both the stove and the fuel?"). This attribute assesses a household's ability to pay for the primary cooking solution (cookstove and fuel). Affordability is measured using the levelized cost of the fuel. A cooking solution is considered affordable if a household spends less than 5% of the total household expenditures on its cooking fuel. In this report, however, Affordability is measured using the cooking fuel expenditure only. The cost of the cookstove is not considered.

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

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

---

[8] In this report, *ventilation* is defined as the use of a chimney, hood, or other exhaust system while using a stove or having doors or windows in the cooking area. The *ventilation* factor helps to mitigate pollutants from cooking. Kitchen volume was not considered for Honduras due to lack of reliable data.

[9] When the cookstove also serves as a source of heating for the dwelling, the Efficiency attribute is ignored because heat transfer efficiency becomes irrelevant.

BOX 3 • TYPOLOGY OF COOKSTOVES IN HONDURAS

In consultation with development partners and government officials, cookstoves in Honduras are classified into five categories (Annex 3):

- **Three-stone stoves** consist of a pot balanced on three stones over an open fire. Fuel use and emissions are high, and thermal efficiency and safety are low. Three-stone stoves usually use firewood, but other solid fuels may be used. Fuel rests on the ground.
- **Traditional cookstoves** (traditional *fogóns* without chimney) are locally produced using mud, metal, or other low-cost materials and following cultural practices. Fire is enclosed in the combustion chamber, which is not fully insulated. The pot is often raised above the fire, allowing more time for combustion. It uses firewood, and fuel rests on the ground.
- **Improved cookstoves** (ICSs) with chimneys have a well-insulated combustion chamber. The chimney takes most of the emission outside the kitchen, producing less indoor and overall air pollution. It uses newer stove technology to improve efficiency, cleanliness, and safety. It uses firewood, and the fuel rests on a shelf.
    - **The rocket stove** (RS) gasifier (*ecofogón*) is an efficient and hot burning stove that uses small-diameter wood fuel. Fuel is burned in a simple combustion chamber containing an insulated vertical chimney, which ensures almost complete combustion prior to the flames reaching the cooking surface. In this report's analysis, RS gasifier is included in the ICS category.
- The **liquid petroleum gas (LPG)** stove typically has a steel cylinder filled with LPG, a pressure controller, a tube connecting the cylinder to the pressure controller and the burner, and the burner. It is convenient because it heats quickly, and the temperature can be precisely controlled. It uses fuel obtained during petroleum refining and consists mainly of butane or propane. LPG fuel can also be obtained from fossil coal. LPG fuel is generally nontoxic, easy to handle, energy efficient, and burns very cleanly. It requires higher capital investment into devices and higher running costs for fuel than for many other stoves.
- The **electric stove** works with electricity and is the cleanest stove type.

A methodology similar to the electricity framework is applied to obtain the aggregate tier for clean cooking solutions. The lowest tier of the attributes is taken as the final tier for a household. (For more information on the threshold and tier calculation, see Annex 1, Table A.2.)

USING THE MULTI-TIER FRAMEWORK TO DRIVE POLICY AND INVESTMENT

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

Insights derived from the MTF data enable governments to set country-specific access targets. The data can be used in setting targets for universal access based on the country's conditions, available resources, 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 provide new connections. They help governments determine the minimum tier the new connections should target.

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

The MTF surveys provide three types of disaggregation: by urban or rural location, by quintile, and by the gender of the household head. For gender-disaggregated data, nonenergy information, such as socioeconomic status, is also collected. Indicators such as primary energy source, tier of access, energy-related spending, WTP, and user preferences are disaggregated by male-headed and female-headed households. Such disaggregated analyses 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 HONDURAS

MTF data collection in Honduras occurred from May 2017 to July 2017. The household survey sample selection was based on a three-stage[10] stratification strategy, designed to be representative of both urban and rural population.[11] MTF Sample Framework is based on the Master Sample, which is based on the last Population and Housing Census, prepared by the National Institute of Statistics (INE) in 2013 (*Censo National de Población y Vivienda 2013*) and published in August 2015. INE provided advice on sampling strategy and supported the MTF team in identifying the electrification status of EAs. The MTF energy survey targeted a sample of 3,324 households (1,668 in rural and 1,656 in urban areas) in 276 EAs, equally split between urban and rural areas, in 16 departments of Honduras. It followed the stratification criteria of 50–50 ratio of electrified and nonelectrified households for the tier analysis and equal allocation between urban and rural areas (Table 3 and Figure 3). The final sample size was considerably reduced due to the high nonresponse rate in urban areas because of safety issues, lowering the actual sample size to 2,815 households (1,574 in rural and 1,241 in urban areas). The sampling strategy is provided in Annex 2.

Another important caveat is that the survey was implemented in 16 out of 18 departments,[12] with the exclusion of the departments of Gracias a Dios and Islas de la Bahía from the survey in line with the INE strategy (ENEE, 2016 and 2017; INE, 2015). The outcomes of the MTF analysis must be read considering these limitations.

[10] The sample of households of the MTF survey was selected from the master sample of sectors (primary sampling unit) in three stages: in the first stage a subsample of sectors was selected from the master sample; in a second stage a segment was selected in each sector of the MTF sample; in the third stage the households were selected within the segments of the MTF sample.

[11] The political division of Honduras comprises 18 departments, 298 municipalities, 3,714 villages and 29,950 caseríos (409 urban and 29,541 rural).

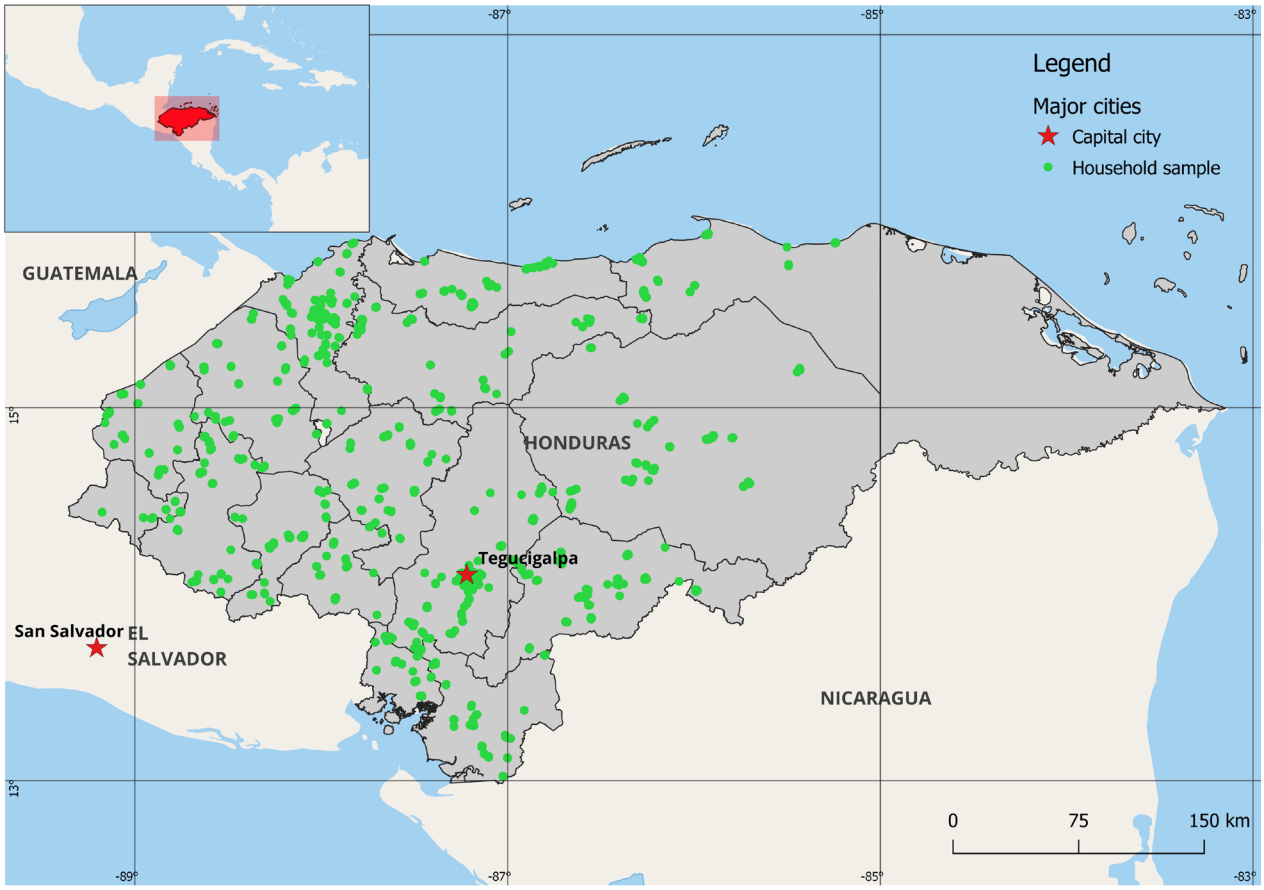
[12] The departments of Gracias a Dios and Islas de la Bahía are excluded from the survey, because they are not included in the master sample of INE. The reasons for this choice are explained in Annex 2.

TABLE 3 • **Distribution of enumeration areas and sampled households, MTF Survey, Honduras**

	Urban				Rural				Total	
	Electrified		Nonelectrified		Electrified		Nonelectrified			
	EAs	HHs	EAs	HHs	EAs	HHs	EAs	HHs	EAs	HHs
Atlántida	8	96	0	0	5	60	0	0	13	156
Colon	4	48	0	0	3	32	3	48	10	128
Comayagua	6	72	0	0	7	84	2	32	15	188
Copan	3	36	0	0	8	88	1	16	12	140
Cortes	48	576	1	12	11	108	1	16	61	712
Choluteca	4	48	0	0	7	80	2	32	13	160
El Paraíso	3	36	0	0	9	92	2	32	14	160
Francisco Morazán	38	456	0	0	11	120	3	48	52	624
Intibucá	2	24	0	0	5	52	2	32	9	108
La Paz	2	24	0	0	4	56	1	16	7	96
Lempira	1	12	0	0	7	68	3	48	11	128
Ocotepeque	1	12	0	0	2	16	2	32	5	60
Olancho	4	48	0	0	10	104	2	32	16	184
Santa Bárbara	4	48	0	0	9	108	2	32	15	188
Valle	2	24	0	0	2	24	2	32	6	80
Yoro	7	84	0	0	6	64	4	64	17	212
Total	**137**	**1,644**	**1**	**12**	**106**	**1,156**	**32**	**512**	**276**	**3,324**

Note: EA = enumeration area; HH = household.
The final sample size is 2,815 households (1,574 in rural and 1,241 in urban areas). The sampling strategy is provided in Annex 2.

FIGURE 3 • **Sample distribution, MTF survey, Honduras**



ACCESS TO ELECTRICITY

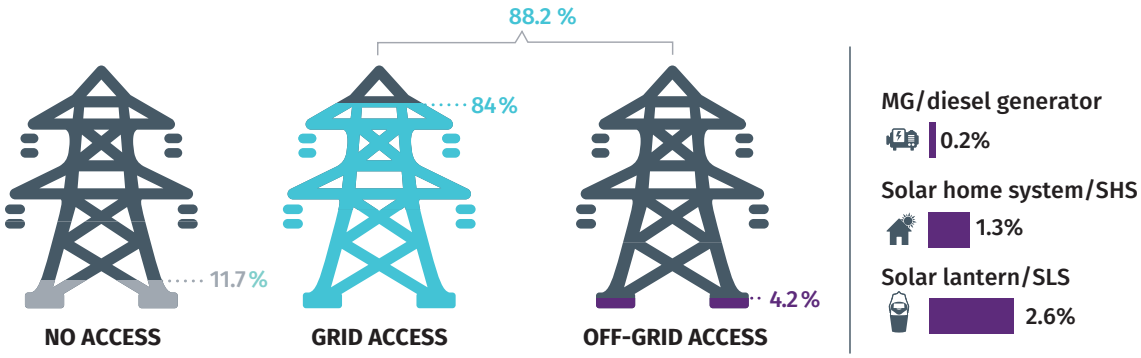
Photo: Lucia Luzi

ASSESSING ACCESS TO ELECTRICITY

TECHNOLOGIES

In Honduras, 88.2% of households have access to at least one source of electricity: most (84%) have access through the national grid, and 4.2% use off-grid solutions (Figure 4). Among the households with an off-grid solution, over half (2.6% of all households) use a solar lantern—typically providing lighting and phone charging—while a very small share (1.3%) use a solar home system (SHS) or a solar lighting system (SLS). Only 0.2% of the household sampled in the MTF survey in Honduras use mini-grid or diesel generator as the main source of electricity.

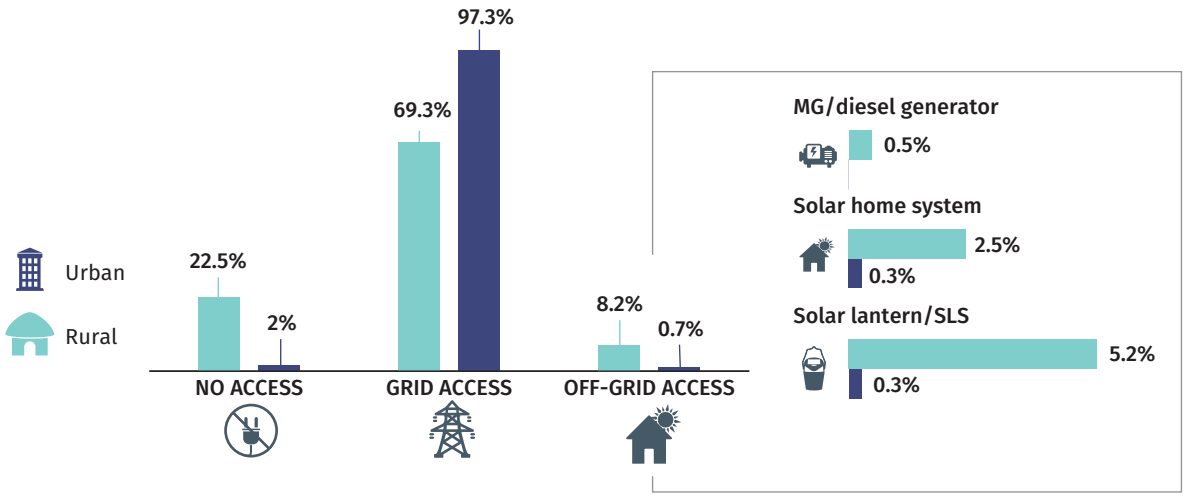
FIGURE 4 • **MTF aggregate tier by expenditure quintile (nationwide)**



Note: Rechargeable battery is 0.1%, present only in urban areas, and, thus, not shown in the graph.

The discrepancy in access to electricity between urban and rural areas is substantial. In urban areas, 98% of households have access to electricity, compared to 77.5% of households in rural areas (Figure 5). Grid access is the main source of electricity in urban areas (almost 97.3%). In rural areas, 8.2% of electrified households have access through an off-grid solution.

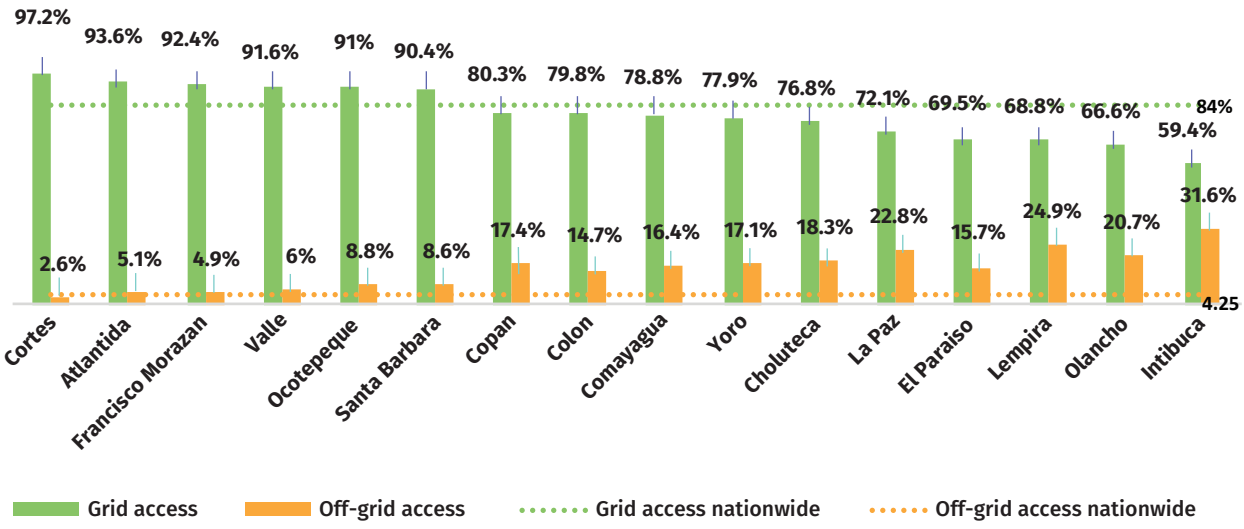
FIGURE 5 • **Access to electricity by technology (urban/rural)**



In Honduras, access to electricity varies across departments (Figure 6). In the department of Cortes, 97.3% of the households have at least Tier 1 access, and 33.5% are in Tier 5. In the department of Atlantida, 94.9% of the households have at least Tier 1 access, and 58.9% are in Tier 5. In the department of Francisco Morazan, home to the capital, Tegucigalpa, 94.5% of the households have at least Tier 1 access, and 52.5% are Tier 5. The rest of the departments shows a much lower grid access rate. The departments of Intibuca (38.9%), Lempira (29.3%), Olancho (26.2%), and La Paz (26.1%) have the highest percentage of Tier 0 households.

The penetration of off-grid solutions varies across departments. The departments with higher grid access rate have lower off-grid usage rate and vice versa. The highest percentage of off-grid households are in the departments of Intibuca (31.6%), Lempira (24.9%), La Paz (22.8%), and Olancho (20.7%).

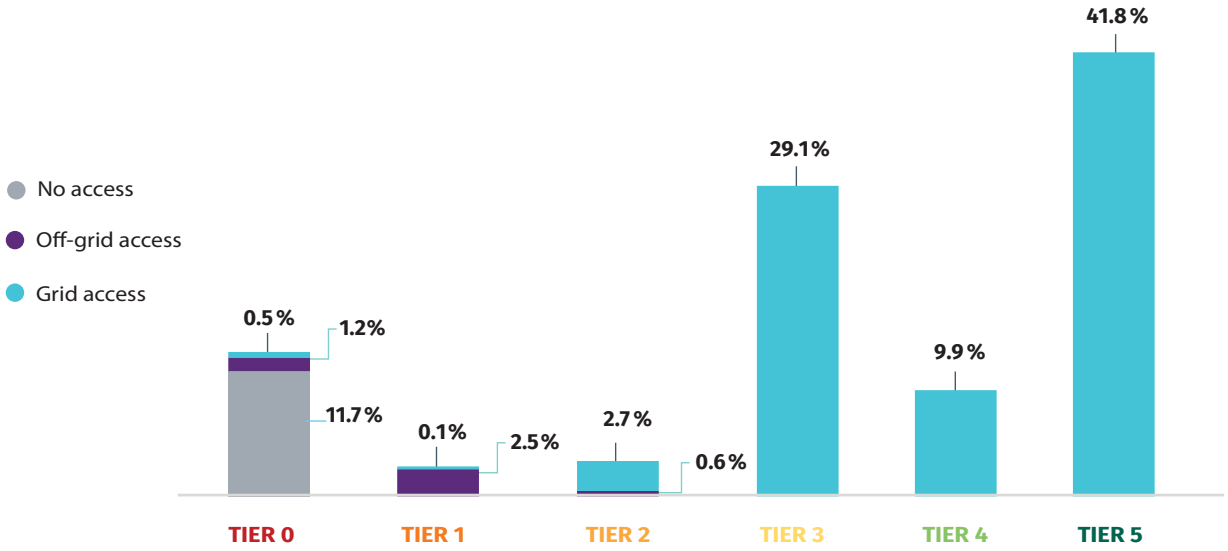
FIGURE 6 • **Access to electricity by technology, by departments**



MTF TIERS

In Honduras, 42% of the electrified households connected to the grid are in Tier 5, and all the households in Tiers 3 through 5 have grid access (Figure 7). Among 13.5% of households that fall in Tier 0, most have no access to any source of electricity. About 1.2% of households using off-grid solutions and 0.5% of households connected to the grid still fall in Tier 0 because their electricity supply does not satisfy Tier 1 requirements (due to the limited Capacity or Availability of off-grid solutions or to the limited Availability of the grid supply). The remaining off-grid households fall in Tier 1 (2.5%) or Tier 2 (0.6%). Grid users are concentrated in Tier 3 or above, with almost 42% of them reaching Tier 5.

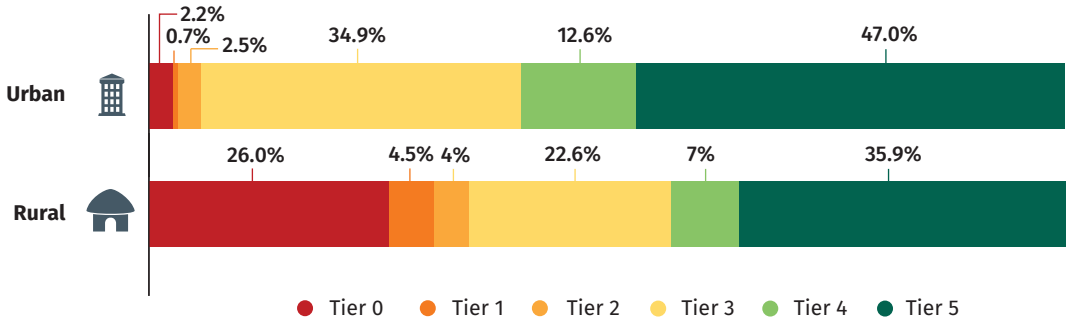
FIGURE 7 • **MTF tier distribution, by technology (nationwide)**



Note: The total number of households connected to the national grid is 2,212; 908 households did not respond to "Reliability" questions.

Electricity access is largely a rural challenge (Figure 8). More than one out of four rural households are in Tier 0 for access to electricity, while the remainder (74%) are dispersed across Tiers 1 through 5. Most urban households are in Tier 5, and about 2.2 remain in Tier 0. As a result, the average tier for urban households is 4, compared to only 2.9 for rural households.

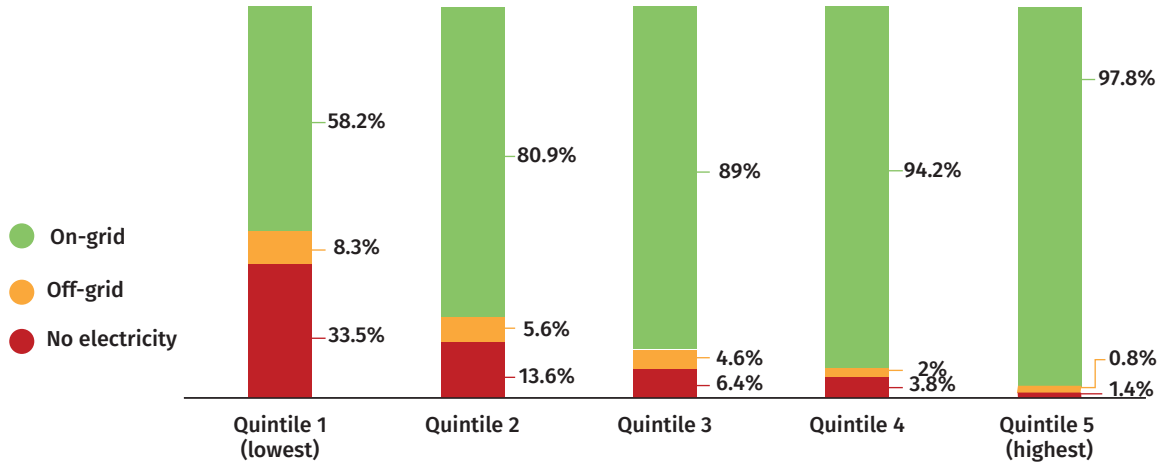
FIGURE 8 • **MTF tier distribution (urban/rural)**



Grid access rate increases with the level of household expenditure (Figure 9). In the highest expenditure quintile, most households (97.8%) have access to the grid, compared to a smaller share (58.2%) of households in the lowest quintile. Off-grid solutions are more common among households in the bottom two spending quintiles than among households outside of these quintiles. This fact suggests that lower-expenditure households benefit more from off-grid solutions (mainly SHSs and solar lanterns or SLSs) because they are more affordable or possibly the only option available when considering the cost of obtaining a grid connection. Nationwide, 71.6% of the households paid the full price upfront for the solar device, 12.3% paid in installments, and 16.1% received it for free (Figure 38).

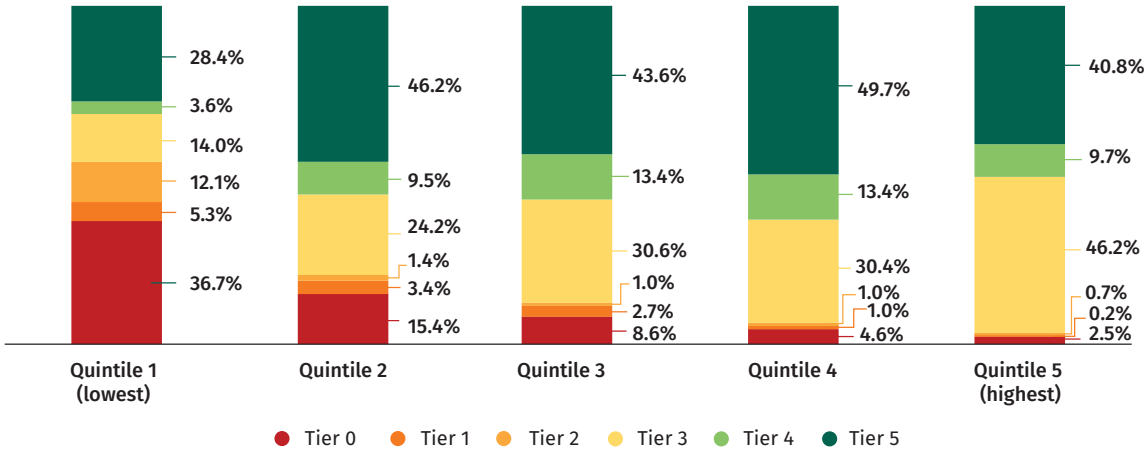
A close examination of the households in the top expenditure quintiles reveals that of the households in quintile 4, 2% use off-grid solutions and 3.8% do not have any source of electricity (Figure 9). On the other hand, of the households in the quintile 5, 0.8% use off-grid solutions, while 1.4% do not have access to electricity. Most of these wealthy household using off-grid solutions or without access to electricity live in rural areas.

FIGURE 9 • **Access to electricity by technology, by expenditure quintile (nationwide)**



Access to electricity is correlated with wealth (Figure 10). While 97.3% of the households in the top spending quintile are in Tier 1 or above and most of them (96.5%) are in Tiers 4 and 5, only 63.4% of the households in the bottom quintile are in Tier 1 or above. Even 36.7% of the bottom expenditure quintile group is in Tier 0. This means that the electricity deficit is concentrated on the poorest households in the country. This disparity reflects mostly the urban-rural divide.

FIGURE 10 • **MTF tier distribution by technology, by expenditure quintile (nationwide)**

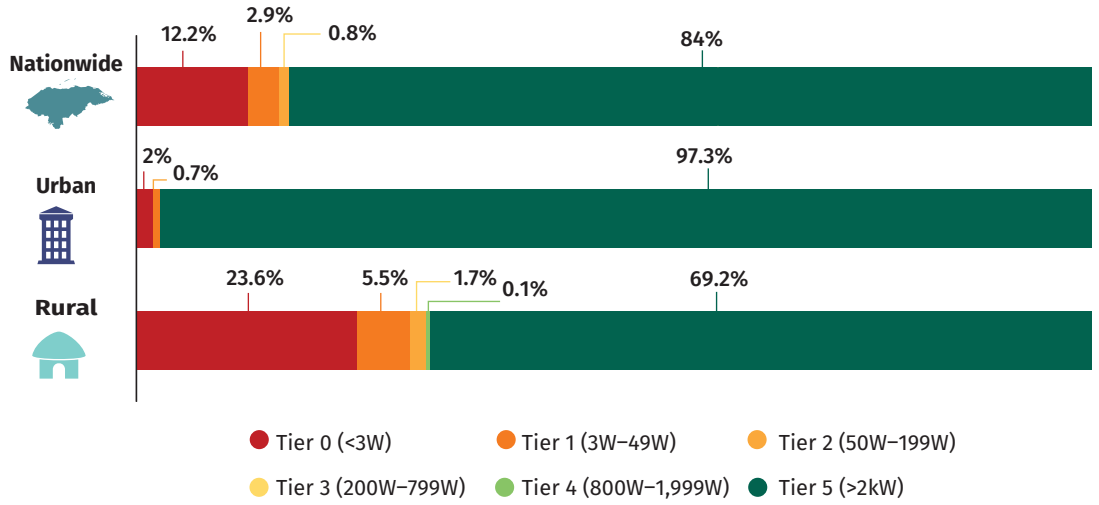


MTF ATTRIBUTES

Capacity

Capacity is the load capacity of the service that households receive from electricity connection. The MTF survey does not measure capacity of the service directly, but attempts to estimate it from household appliance usage.[13] Because grid-connected households are considered to be receiving high-capacity electricity (over 2,000 watts), the share of households that receive high-capacity electricity is the same as the share of households connected to the grid (84%) (Figure 11). The capacity of off-grid solutions typically ranges between 3W and 49W for 2.9% of the households, while only 0.8% of households have a larger off-grid solution (50W to 199W). While 97.3% of the urban households receive high-capacity electricity, 69.2% of the rural households do, because the penetration of off-grid solutions that provide limited capacity is higher in rural areas.

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



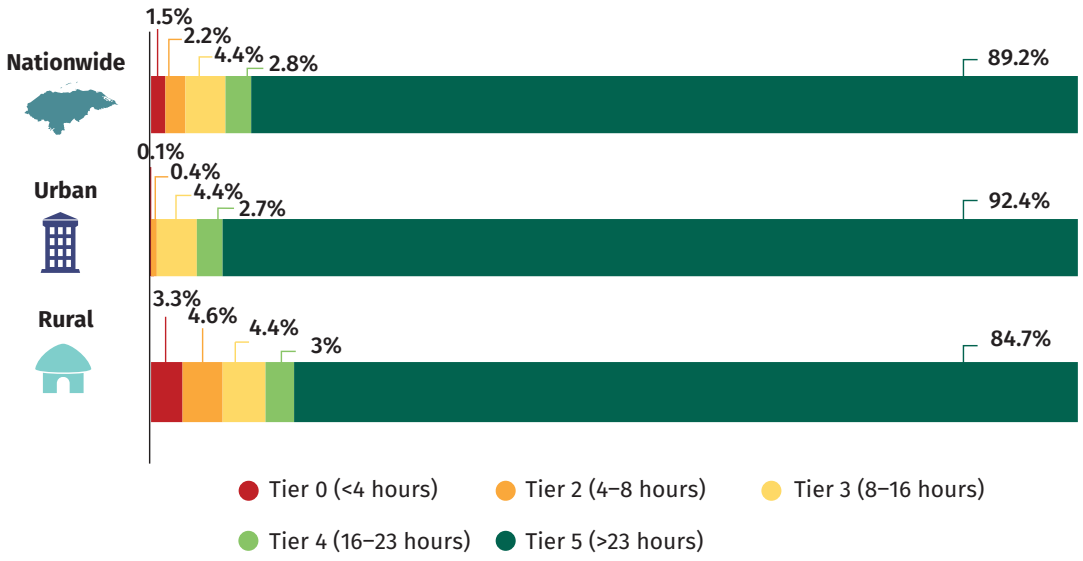
Note: Sample size = 2,815 households; all households.

Availability

The Availability attribute corresponds directly to availability of electricity service during the day (24 hours) and in the evening (four hours after sunset) as outlined in Table A.1 in Annex 1. Figures 12 and 13 show household distribution by availability. Availability of electricity service day and night is an important attribute. Availability of electricity supply is not a major constraint for most of the households. About one out of 10 of the households in Honduras have limited Availability of electricity (less than 23 hours per day) (Figure 12). In rural areas, limited Availability is more acute: 12.3% of rural the households receive less than 16 hours a day of electricity, compared with 5% of the urban households that have the same level of access. Further, 96.6% of the households nationwide receive adequate electricity supply in the evening (between 6 p.m. and 10 p.m.), making it a problem only in rural areas, where 6.8% of the households receives less than four hours of service per night (Figure 13).

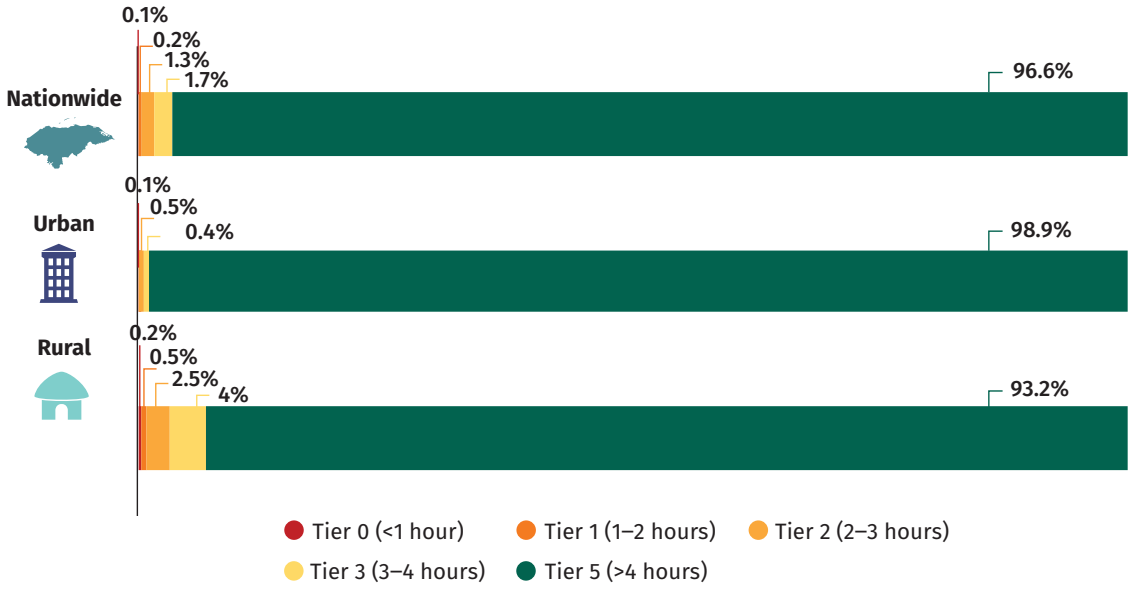
[13] The distribution of off-grid households by tiers of Capacity attribute is shown in Figure 36.

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



Note: Sample size = 2,376 households; only households with access to an electricity source.

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

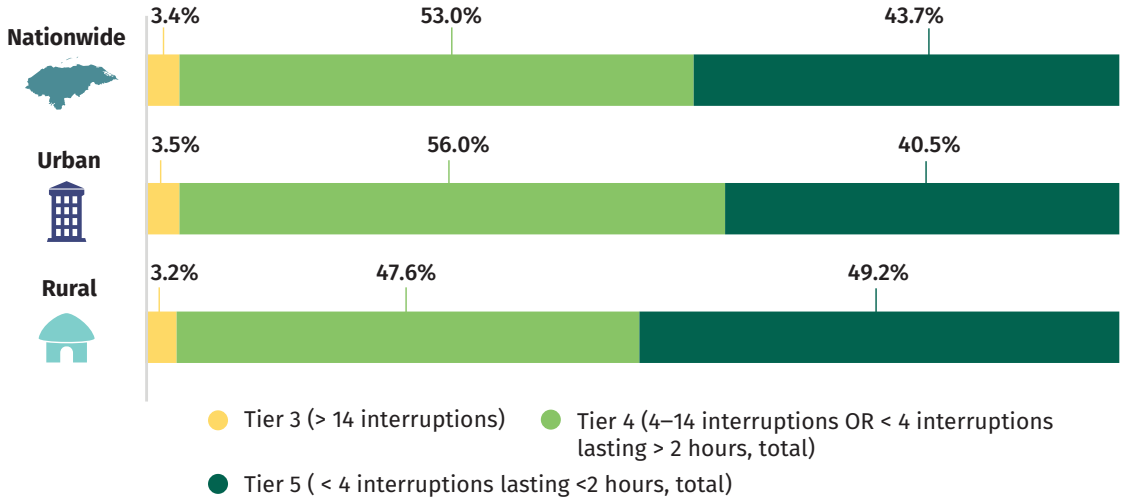


Note: Sample size = 2,376 households; only households with access to an electricity source.

Reliability

The Reliability attribute captures the frequency and duration of unscheduled outages, and it applies only to grid-connected households. About 56.4% of the grid-connected households face frequent, unpredictable power outages (Figure 14). Most suffer from 4 to 14 interruptions per week lasting over two hours in total. Results are similar across urban and rural households. Nationwide, the average duration of outages per week for grid-connected household is 9.2 minutes during a typical month, and 14.6 minutes during the worst months.[14]

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

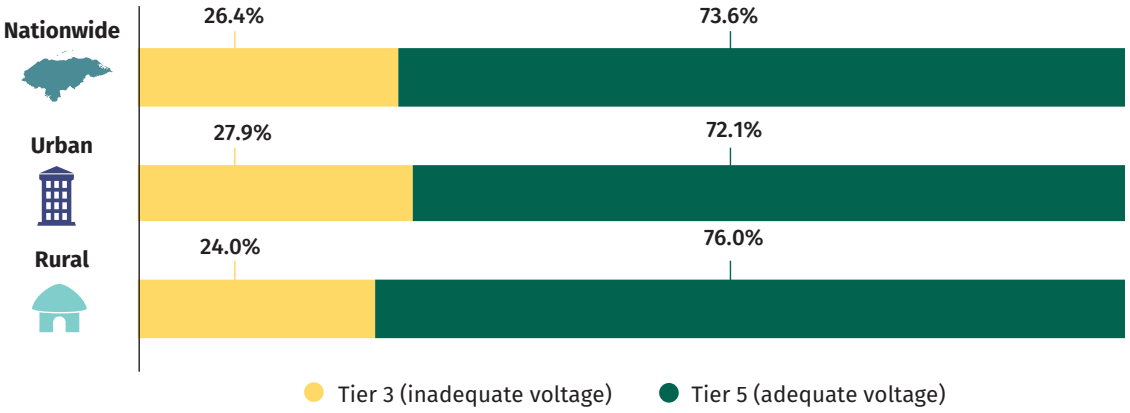


Note: Sample size = 908 households; only grid-connected households.

Quality

The Quality attribute applies only to households on either the national grid or mini-grids. Electric appliances generally require a certain voltage supply to operate properly. In Honduras, 26.4% of the grid-connected households face voltage issues, such as low or fluctuating voltage, resulting in appliance damage (Figure 15).

FIGURE 15 • **Distribution of households based on electricity Quality (nationwide, urban/rural)**



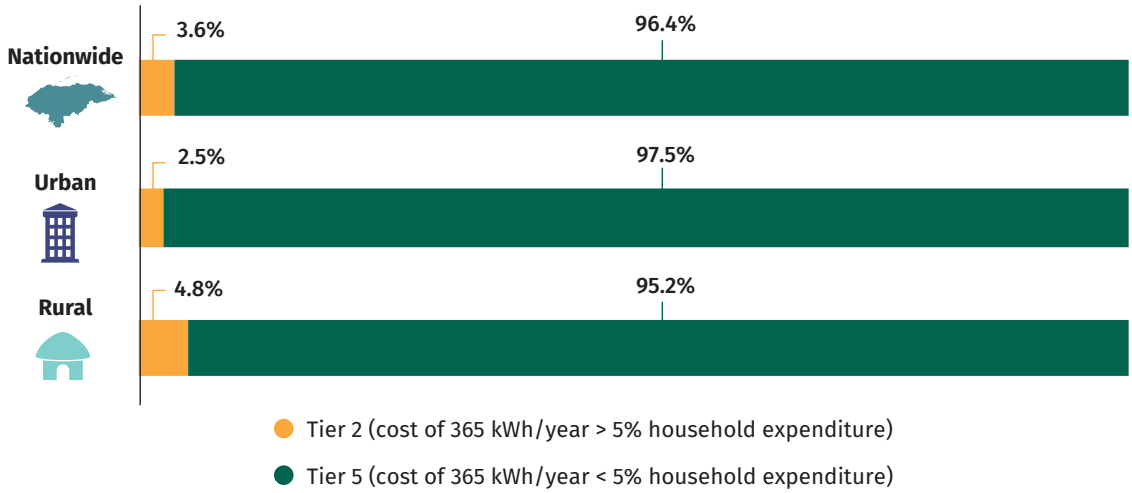
Note: Sample size = 2,212 households; only grid-connected households.

[14] The worst months indicated by the interviewed households were MayJuly.

Affordability

The Affordability attribute measures the percentage of households that can afford subsidized electricity.[15] About 3.6% of Honduran households cannot afford to pay for basic electricity services, corresponding to 365 kWh per year (Figure 16). For 4.8% of the rural households and 2.5% of the urban households, more than 5% of their household spending is needed for this basic electricity. For both urban and rural households, Affordability, therefore, is a constraint in electricity consumption; however, rural households consume about half of what urban households consume (see Figure 19). On average, households consume more than the basic service package, and spend about 7% of their budget on electricity in rural and urban areas, respectively.

FIGURE 16 • **Distribution of households based on electricity Affordability (nationwide, urban/rural)**



Note: Sample size = 2,212 households; only grid-connected households.

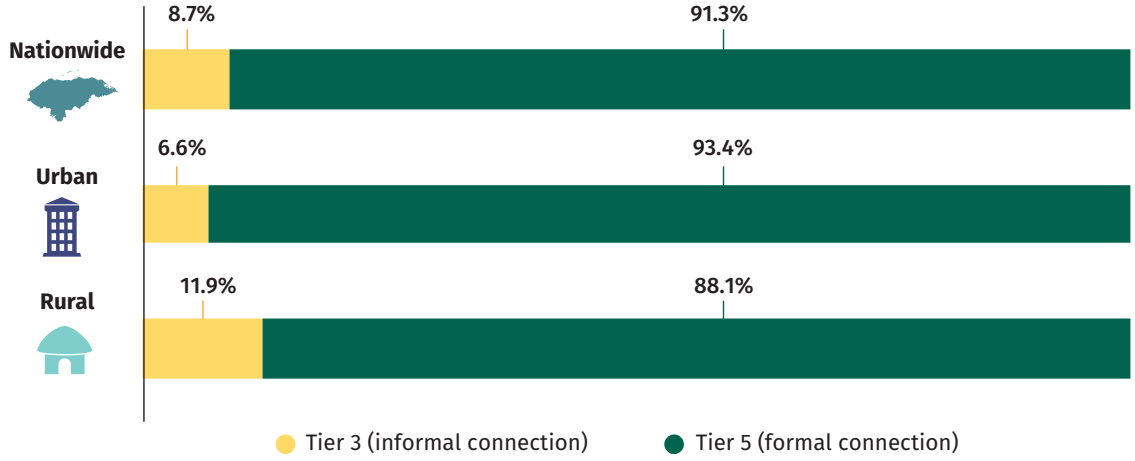
Formality

Formality refers to a household's grid connection provided or sanctioned by the authority.[16] Informal connections are those obtained by means not authorized by the electricity company, such as those made by diverting cables from the outdoor electric line. Reporting on Formality is challenging because households may be sensitive about disclosing such information in a survey. The MTF survey infers information on Formality from indirect questions that respondents may be more willing to answer (such as what method a household member uses to pay the electricity bill), so the actual percentage of households with an informal connection may differ from the data reported here. More than nine out of ten grid-connected households are reported to have a formal connection (Figure 17).

[15] The electricity tariff in Honduras is HNL1.62/kWh (US$0.06). Capturing income through survey questionnaire is often difficult because of its sensitive nature. Therefore, MTF calculation uses household consumption expenditure as proxy for income. This package includes only recurring costs of electricity consumption, not any fixed or one-time cost such as connection cost or cost for internal wiring.

[16] MTF estimations consider only residential customers.

FIGURE 17 • **Distribution of households based on Formality (nationwide, urban/rural)**

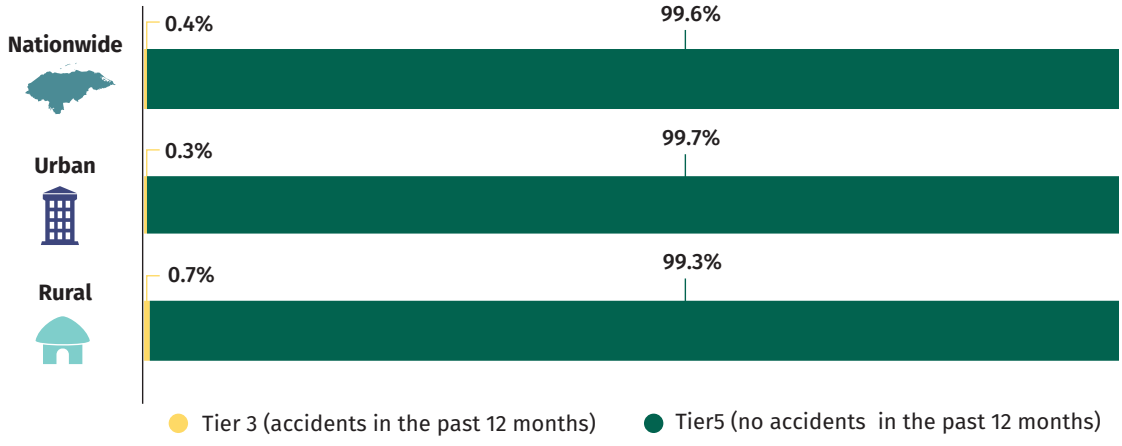


Note: Sample size = 2,212 households; only grid-connected households.

Health and Safety

Health and Safety attribute refers to any injuries to household members from using electricity service from the grid during the preceding 12 months of the survey. Electricity access is considered safe when users have not suffered from past accidents due to their electricity supply, resulting in permanent injuries. Health and Safety issues do not seem to occur widely in Honduras: only 0.4% of grid-connected households report accidents causing permanent injury or death (Figure 18). It is, however, important to ensure that all households are aware of basic safety measures and that wiring is installed according to national standards to prevent accidents when operating electricity under both normal and fault conditions.

FIGURE 18 • **Distribution of households based on Health and Safety (nationwide, urban/rural)**



Note: Sample size = 2,212 households; only grid-connected households. Only 14 households out of 2,212 reported an accident related to electricity.

USE

Data on household electricity consumption and the use of appliances are collected and examined because these can provide policy makers with valuable insights. Grid-connected households consume an average 130 kilowatt-hours monthly. Urban households consume almost double the consumption of rural households, respectively, 170 kilowatt-hours a month and 82.6 kilowatt-hours a month (Figure 19). Spending on electricity accounts for 7% of average monthly household expenditure. The shares are slightly larger (8%) among urban households (HNL 644.8 or US$27.3 a month) and slightly lower (6%) among rural households (HNL 333, or US$14.1 a month) (Figures 20 and 21). These consumption figures are higher than the basic consumption package considered in the discussion of Affordability attribute, which is about 30 kWh/month. This may explain why the Affordability attribute shows that electricity is affordable to 96.4% of the population in the country. Rural households with access to the national grid have been electrified for less than seven years, compared with 14 years among corresponding urban households, which means that national grid connections are relatively new in rural areas.

FIGURE 19 • **Monthly household average consumption of electricity**

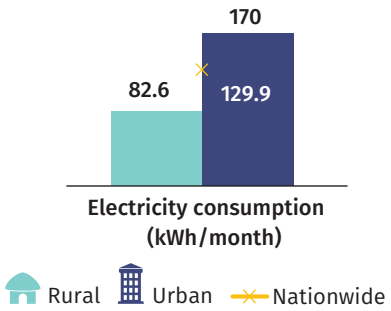


FIGURE 20 • **Monthly household average expenditure on electricity**

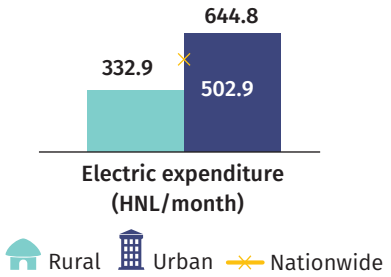
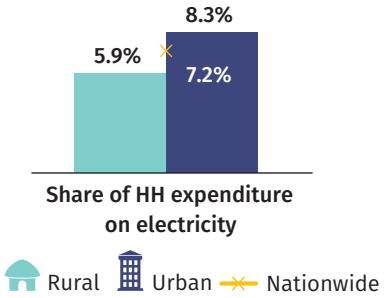
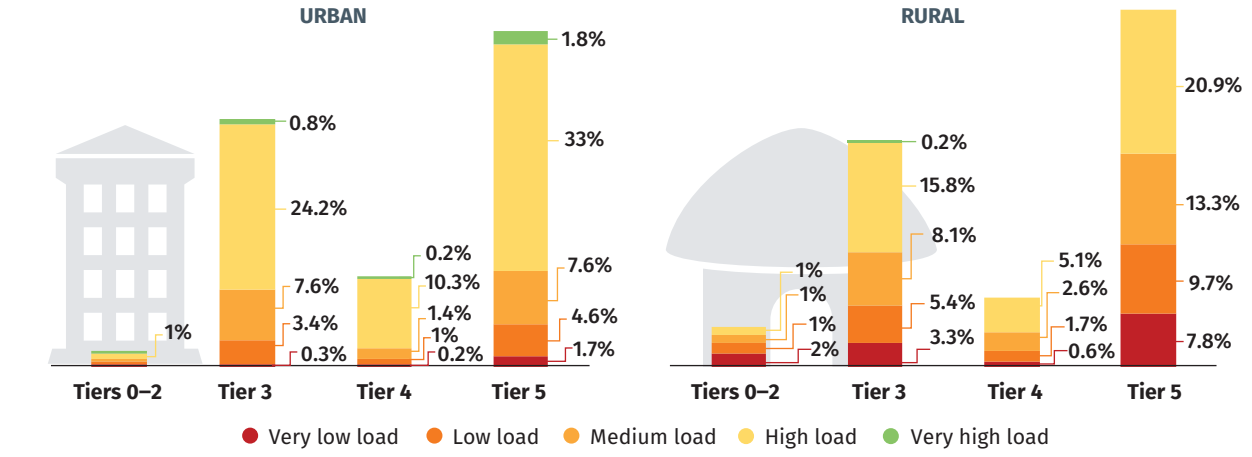


FIGURE 21 • **Spending on electricity as a share of total household spending**



In Honduras, urban households tend to own more higher-load appliances relative to rural households. Overall, 19.7% of the households with grid access (typically those in Tier 3 or above), rely on very low– or low-load appliances, such as lighting or mobile phone chargers in the former case, and televisions or fans in the latter case. This is particularly true for those in rural areas, in which 13.4% and 18.3% of grid-connected households use only very low– or low-load appliances, respectively. In contrast, 2.5% and 9.4% of urban grid-connected households use such appliances, respectively (Figure 22).

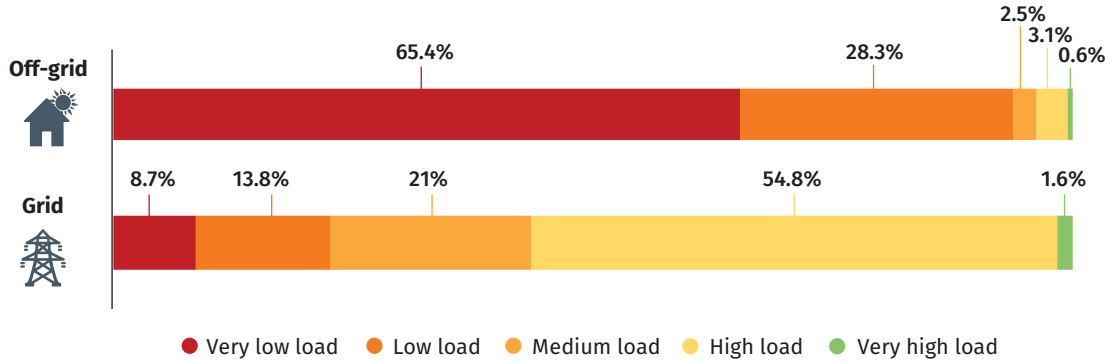
FIGURE 22 • **Power level of the appliances used among households (urban/rural)**



Note: Sample size = 2,212 households; only grid-connected households.

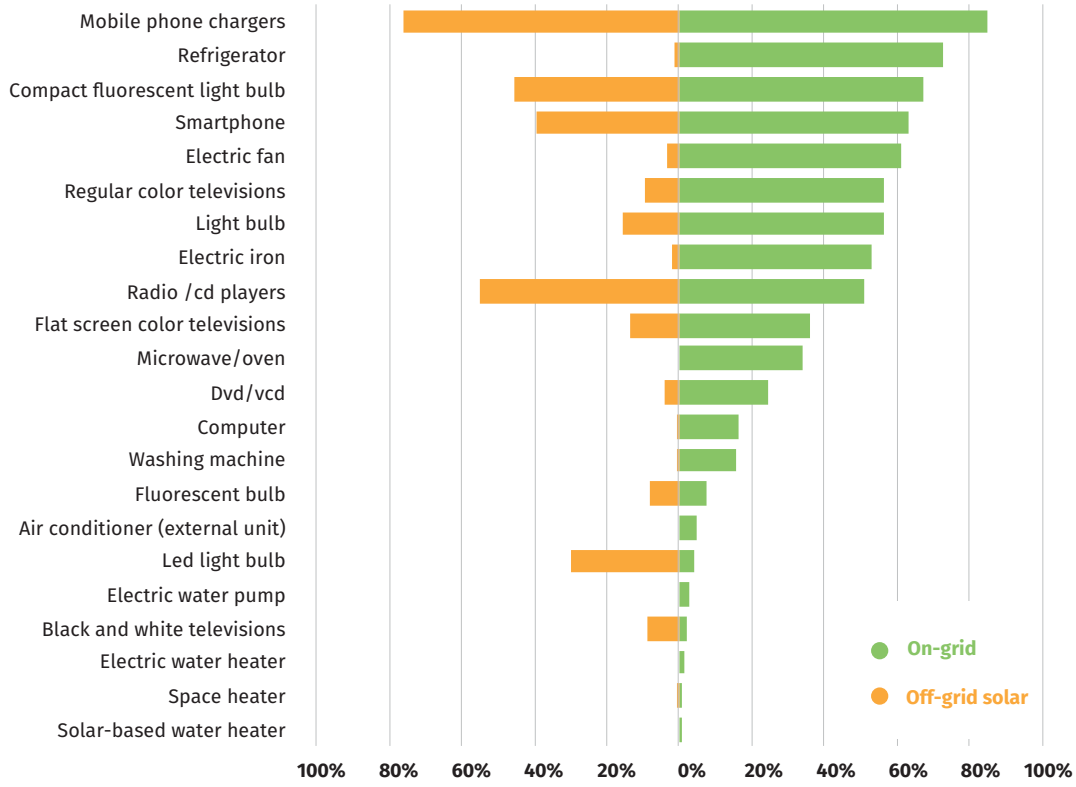
Among off-grid users, the majority uses low- or very low–load appliances (Figure 23). Households that use an off-grid solar device mostly used it for charging either a regular mobile phone (76.2%) or smartphone (39.2%), using a radio or CD player (55.1%), or for compact fluorescent light bulb use (45.4%) (Figure 24).

FIGURE 23 • **Appliance power distribution within each aggregate tier by grid and off-grid users (nationwide)**



Note: Sample size = 2,212 grid-connected households and 164 off-grid households.

FIGURE 24 • **Appliance ownership by grid and off-grid users (nationwide)**



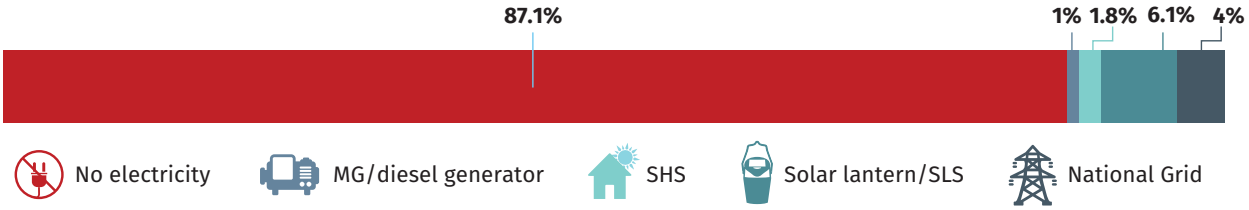
Note: Sample size = 2,212 grid-connected households and 164 off-grid households. The percentage for light bulb refers to households that own a compact fluorescent light bulb, a fluorescent tube, an incandescent light bulb, or a LED light bulb. The percentage of television ownership refers to households that own a regular color, flat-color, or black-and-white television.

IMPROVING ACCESS TO ELECTRICITY

In electricity access, 13.5% of the Honduran households are in Tier 0, and nearly all of these households are in rural areas (Figures 7 and 8). Of those households in Tier 0, 87.1% have no electricity source,[17] about 9% use off-grid energy solutions, and the remaining 4% are connected to the national grid (Figure 25). The households that use a solar device are classified in Tier 0 because their electricity supply does not meet the Capacity and Availability criteria for Tier 1. Strategies for elevating households from Tier 0 will depend on why households are in that tier: for example, connecting households with no electricity source to on- or off-grid solutions and tackling issues in Capacity and Availability attributes for off-grid energy solution users.

MTF attributes analyses show that Quality and Reliability are the main issues for grid users, followed by issues related to Formality. Thus, improving these attributes for national grid can raise grid users to the highest tier. Different policies are required for households that do not have access to any source of electricity, households that have off-grid access but remain in Tier 0, and households connected to the grid but have not reached Tier 5.

FIGURE 25 • **Tier 0 disaggregation by source of electricity**



The share of households in Tier 0 in nongrid-electrified EAs or those without grid infrastructure, is much higher in rural (5.9%) than in urban (0.2%) areas. Conversely, the share of households in Tier 1 or above is much higher in urban (51.3%) than in rural (35.2%) areas (Table 4). The share of households in Tier 0 in grid-electrified EAs is higher in rural (6.5%) than in urban (1%) areas. As indicated, 86.5% of the population would benefit from investments to improve the quality of their grid or off-grid service, with most benefits accruing to urban households. About 7.4% of the population would benefit from policies to increase the number of last-mile grid connections, benefiting more rural households than urban. A final 6.1% of the population would benefit from grid extension to electrify the EA. Because these households are mainly rural, that investment would likely require policy support to incentivize connections.

TABLE 4 • **Distribution of households by tiers (nationwide, urban/rural)**

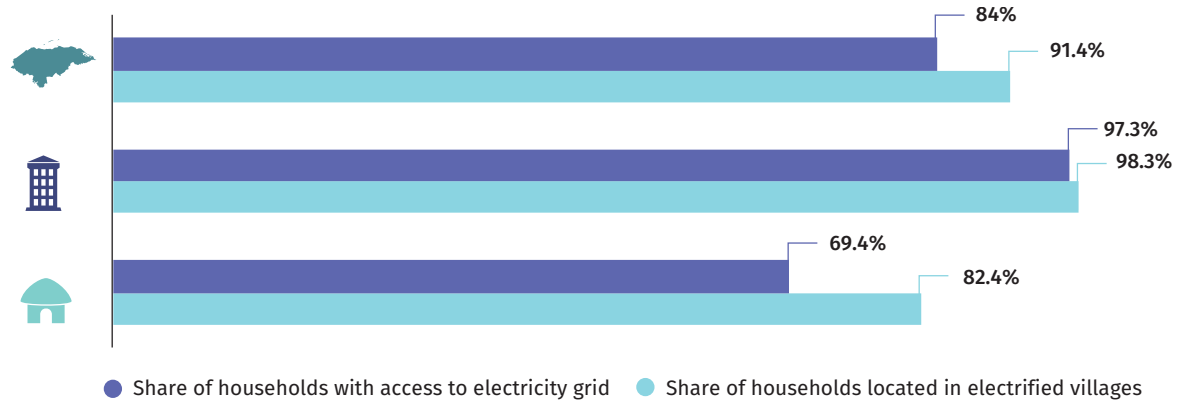
	Households in Tier 0 (EAs)		Households in Tier 1 or higher	Total
	Nongrid-electrified	Grid- electrified		
Urban	0.2%	1%	51.3%	52.5%
Rural	5.9%	6.5%	35.2%	47.5%
Nationwide	6.1%	7.4%	86.5%	100%

[17] Dry-cell battery is not counted as source of electricity.

PROVIDING ELECTRICITY ACCESS TO HOUSEHOLDS WITHOUT AN ELECTRICITY SOURCE

About 84% of households in Honduras are connected to the grid. However, 91.4% of households are in EAs that have a grid (i.e., in EAs in which at least one household is connected to the grid) (Figure 26). The uptake rate is the ratio between the percentage of electrified households over the percentage of electrified villages (EAs). In Honduras, the national uptake rate is 91.4%; 98.3% of urban households in proximity to the grid are connected, while 82.4% of rural households are. Thus, densification projects may enable about 7.4% of households nationwide to get access to the existing grid.

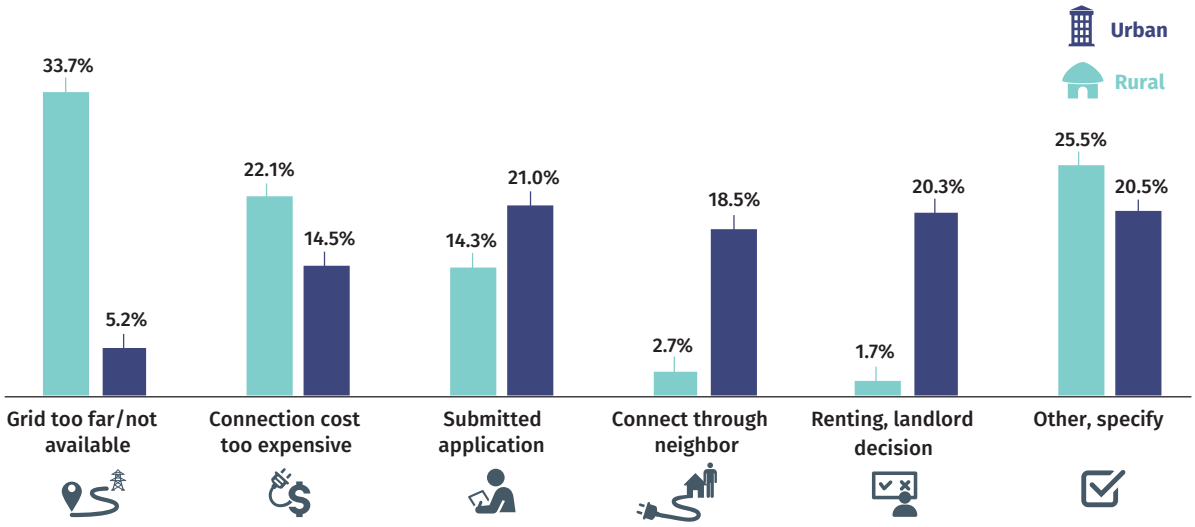
FIGURE 26 • **Comparison of electrification rate between villages (EA) and households (nationwide, urban/rural)**



Note: Households living in the village (EA), where at least one household has a grid connection, are defined as being under the grid.

Lack of grid infrastructure and high upfront cost of acquiring the connection are the most common barriers preventing rural households from gaining access to the grid (Figure 27). Since households without any source of electricity is more likely to be poorer compared to households with either grid or off-grid access, upfront connection cost is more burdensome for them to be connected to the grid. (see Figure 9).

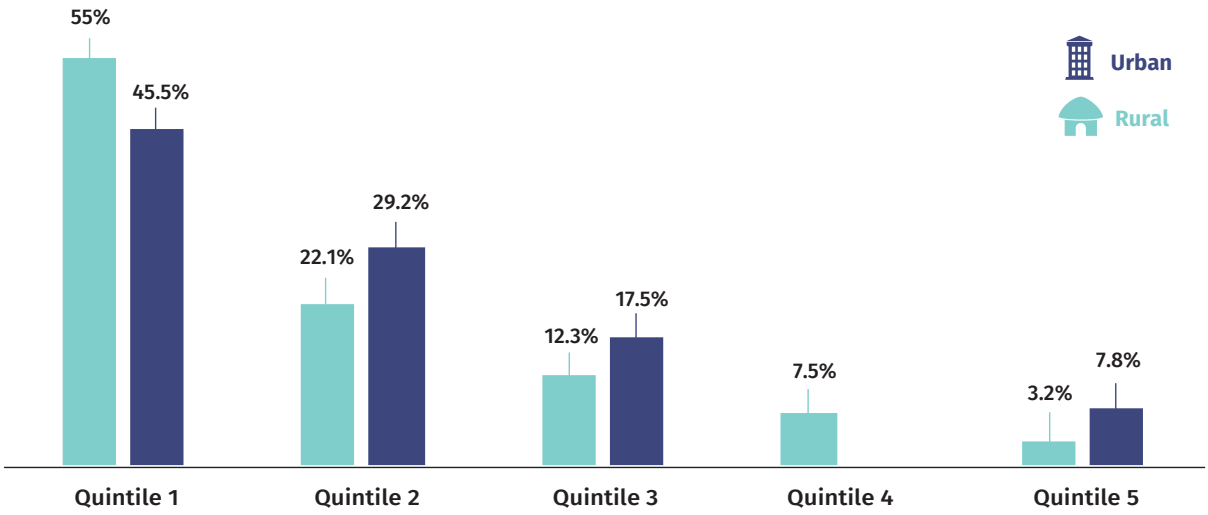
FIGURE 27 • **Barriers to gaining access to grid electricity among households not connected to the grid (urban/rural)**



Note: Sample size = 796 households (rural, 645; urban, 151); only households that are not connected to the grid.
"Other" category includes, among the others: monthly fee too expensive; company refused to connect; complicated administrative process.

A closer look at households' total monthly expenditure shows that nonconnected urban and rural households are likely to be either among the poorest households that requires additional support to be connected (Figure 28).

FIGURE 28 • **Expenditure quintile distribution for households without electricity (urban/rural)**

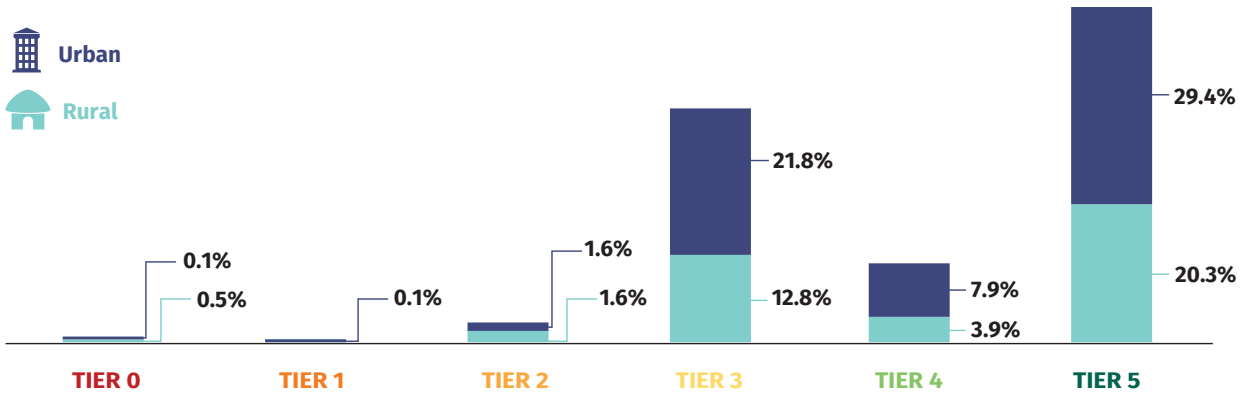


Note: Sample size = 2,212 households; only households that are not connected to the grid.

IMPROVING ELECTRICITY ACCESS FOR GRID-CONNECTED HOUSEHOLDS

The performance of the grid in Honduras is fairly satisfactory: more than six in ten grid-connected households are in Tiers 4 or 5 (Figure 29). The remaining households are primarily in Tier 3 (34.6%), while a few (3.9%) fall in the lower tiers. The largest shares of rural and urban grid-connected households are in Tier 5 (20.3% and 29.4%, respectively); however, 46.4% of the households are in Tiers 3 and 4, mainly due to voltage fluctuations (Quality issue) and frequent interruptions (Reliability issue).

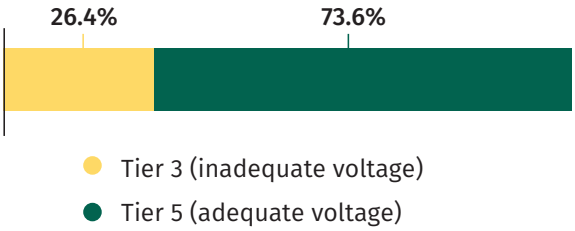
FIGURE 29 • **MTF tier distribution of grid-connected households (urban/rural)**



Note: Sample size = 2,212 households; only grid-connected households.

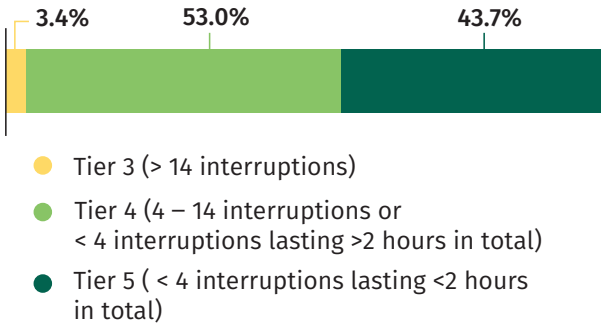
Poor Quality and Reliability—even Formality in a minor way—are the main issues preventing 50.3% of the grid-connected households from reaching Tier 5 access. Quality is a major obstacle for more than a quarter of grid-connected Honduran households: they reported voltage issues resulting in appliance damage (Figure 30). Further, Reliability issues affect 56.4% of grid-connected households, because they experience between 4 and 14 power outages per week, lasting more than 2 hours in total (Figure 31). Finally, 8.7% of the grid-connected households nationwide reported an informal connection to the grid, resulting in a categorization of Tier 3 for Formality (a scenario slightly more common among rural households, according to the respondents) (Figure 32).[18] Availability, Affordability, and Health and Safety are not major issues for grid-connected households.

FIGURE 30 • **Distribution of grid-connected households based on Quality (nationwide)**



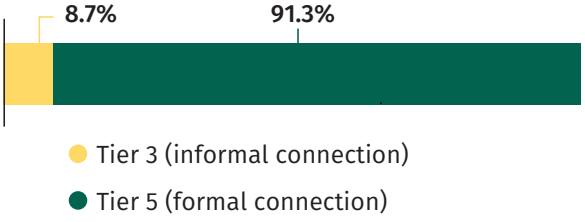
Note: Sample size = 2,212 households; only grid-connected households

FIGURE 31 • **Distribution of grid-connected households based on Reliability (nationwide)**



Note: Sample size = 908 households; only grid-connected households.

FIGURE 32 • **Distribution of grid-connected households based on Formality (nationwide)**

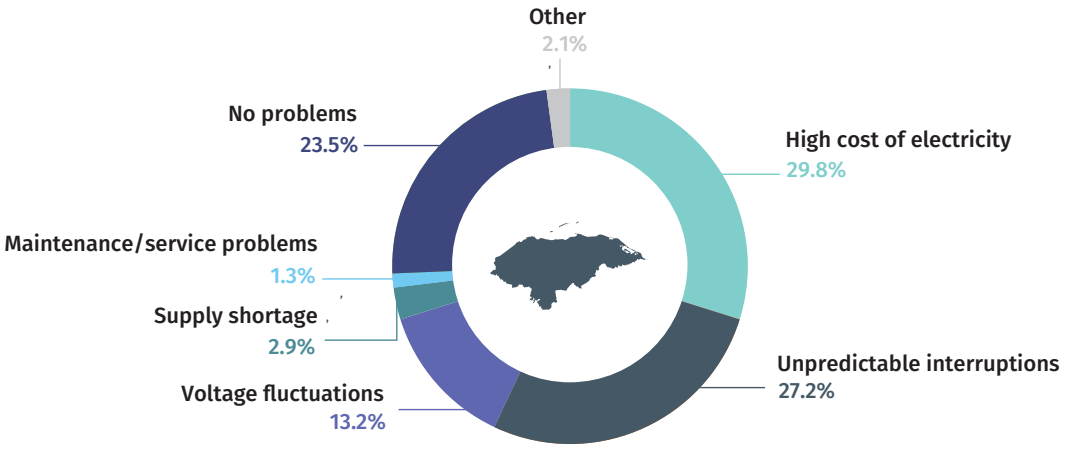


Note: Sample size = 2,212 households; only grid-connected households.

Grid-connected households were asked about problems they face with electricity service. The most frequent problem reported by the households is Reliability, given that 27.2% of grid users experience unpredictable interruption. Affordability represents another issue, because 29.8% of grid-connected households consider that their electricity bill is too high. Finally, grid users experience voltage fluctuations (13.2%), affecting the Quality of the supply (Figure 33). Even though these findings are based on consumer perception of key issues, and are, therefore, more subjective than those analyzed in MTF attributes, the responses are consistent with the MTF findings.

[18] In 2015, the system had high levels of electricity losses registered at 33%, most from nontechnical losses. The MTF energy survey considers only residential customers. This issue is addressed in an indirect way given the difficulties to have people acknowledge they are informally connected to the grid.

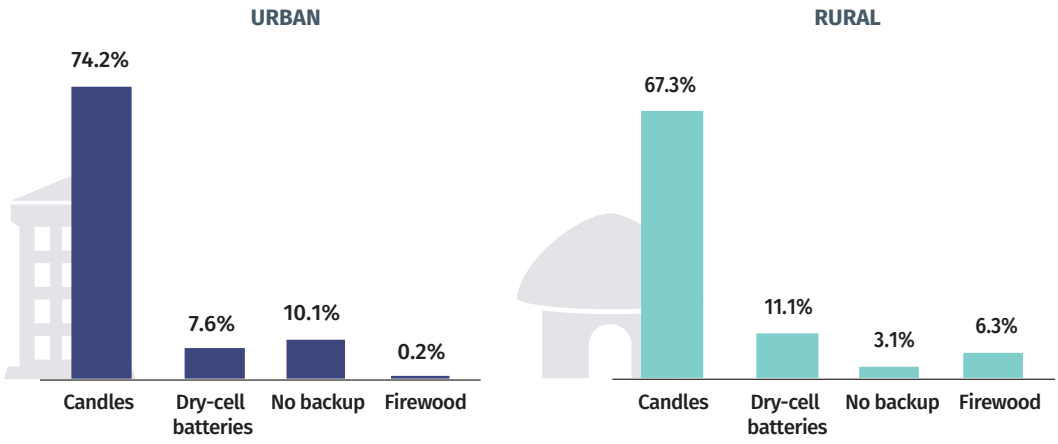
FIGURE 33 • **Main issues cited, related to grid electricity supply (nationwide)**



Note: Sample size = 2,212 households.

To cope with power outages, more than 7 out of 10 of grid-connected households use candles as a backup source for lighting (67.3% of rural and 74.2% of urban households). Around 9% of households use flashlights powered with dry-cell batteries (11.1% of rural and 7.6% of urban households). Nationwide, 7.3% of the grid-connected households do not have any backup source of lighting; having no backup is higher among urban (10.1%) than rural (3.1%) households (Figure 34).

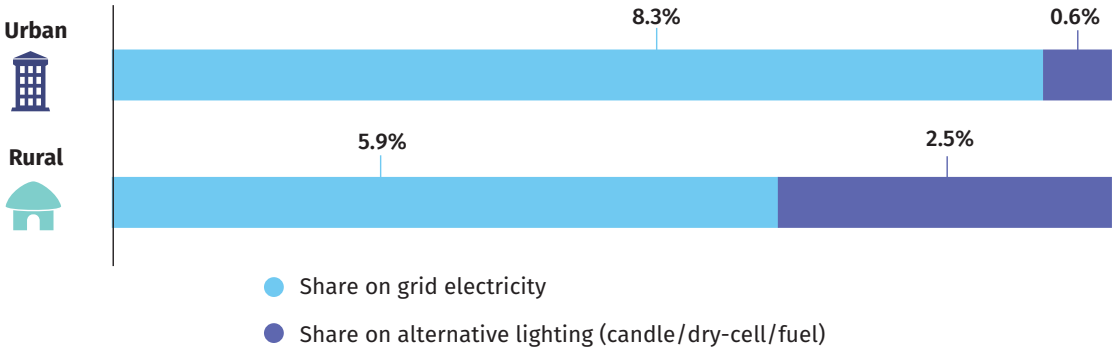
FIGURE 34 • **Distribution of grid-connected households by backup energy source for lighting (urban/rural)**



Note: Sample size = 2,212 households.

Improving the Quality and Reliability of the electricity supply could help reduce the burden of energy spending, and shift spending on backup sources toward higher consumption of electricity. Spending on a backup source of lighting accounts for 2.2% of Honduran household monthly spending. Since households already spend a even a small increase in that spending would put a strain on a household's budget. This is particularly true for rural households, for which 2.5% of the monthly spending goes to backup sources, compared with 0.6% for the urban households (Figure 35).

FIGURE 35 • **Share of household expenditure on backup sources (urban/rural)**



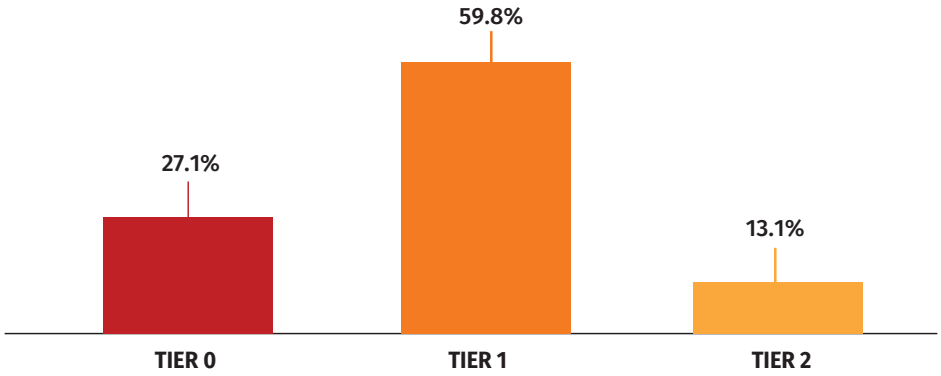
Note: Sample size = 2,212 households.

IMPROVING ELECTRICITY ACCESS FOR HOUSEHOLDS WITH OFF-GRID SOLAR SOLUTIONS

Off-grid solutions tend to fill the electrification gap when grid electricity is unavailable.[19] In Honduras, 4.2% of the households use an off-grid solution as their primary source of electricity, and more than half of those households use a solar device, mainly a solar lantern (see Figures 4 and 5). More than 90% of off-grid solar households reside in rural areas.

In terms of tiers, with a specific focus on solar devices, more than one over four of off-grid solar households fall in Tier 0 because of the limited Capacity of their device about one six over ten reach Tier 1, and only 13.1% have access at a Tier 2 level (Figure 36).

FIGURE 36 • **MTF tier distribution of off-grid solar households (nationwide)**

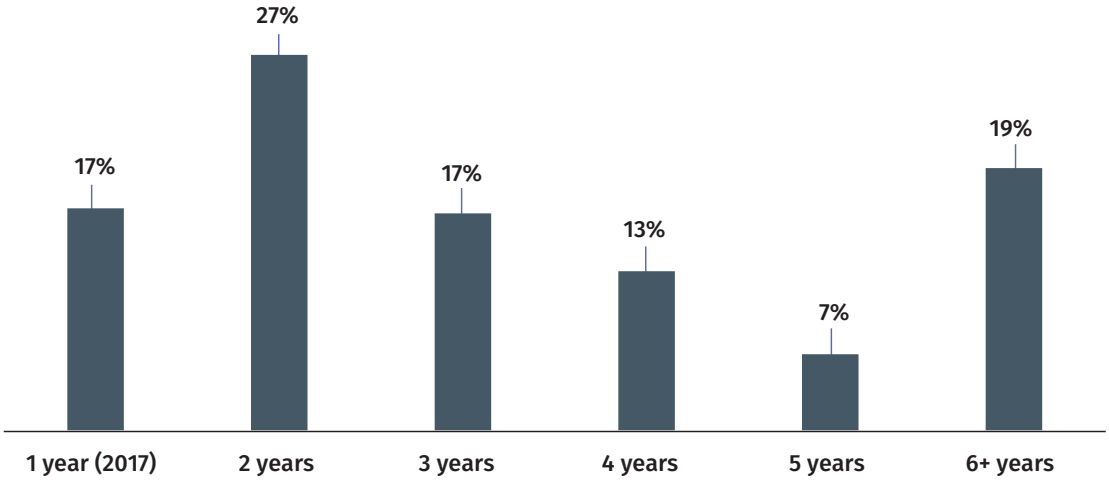


Note: Sample size = 149 households; only households using a solar device as their primary source of electricity.

[19] In Honduras, off-grid user household are those with only SHS and SLS as their main source of electricity, given that the other off-grid components are not common in the country. This means that such sources as mini-grid, diesel generator, or rechargeable batteries, which are usually included in the off-grid users' definition, are excluded from this analysis.

The wide-spread use of solar solutions is a relatively recent phenomenon in Honduras. About 81% of the households in the country obtained their first solar device just within the past five years, and 60% did so within the past three years (Figure 37).

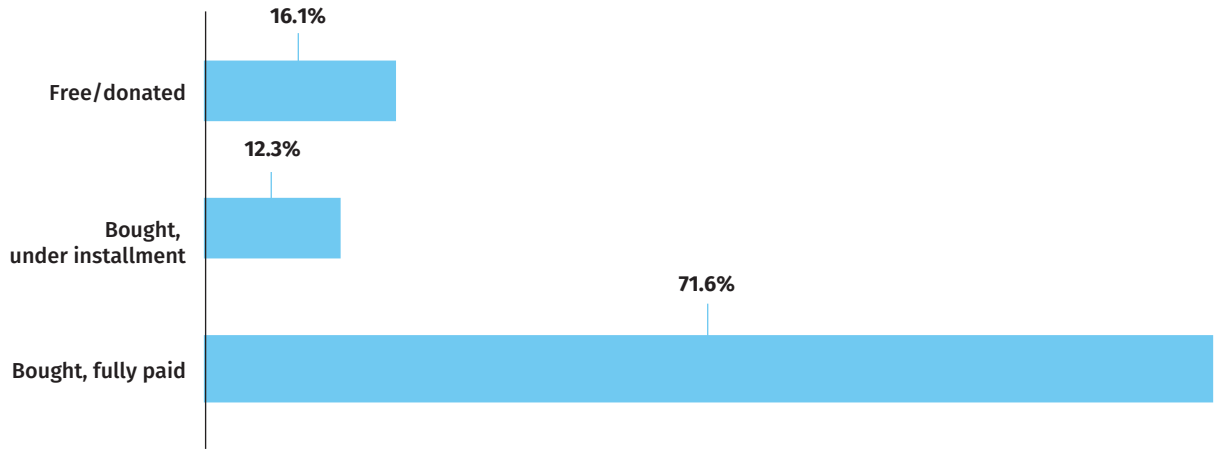
FIGURE 37 • **Number of years using solar solutions (nationwide)**



Note: Sample size = 149 households; only households that use a solar device.

Among households that use a solar device, 83.9% purchased it (Figure 38). Among those who purchased a solar device, 71.6% paid the full price upfront, and 12.3% paid in installments. Only 16.1% of the households received their device for free.

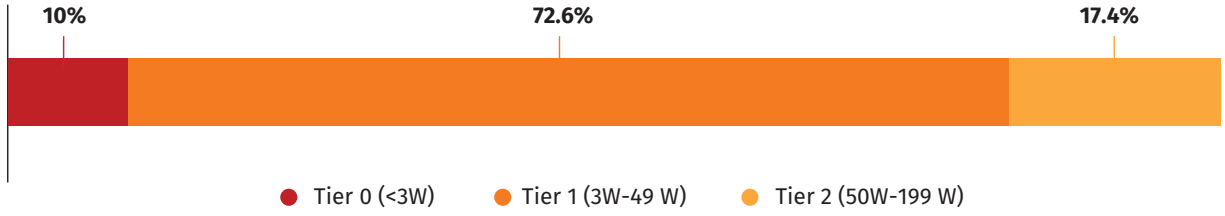
FIGURE 38 • **Solar device acquisition modality (nationwide)**



Note: Sample size = 149 households; only households using a solar device as their primary source of electricity.

Almost all off-grid solar households with Tier 0 access have Capacity constraints because their device provides less than 3 watts (or less than 12 watt-hours) per day (Figure 39). About three out of four off-grid solar households reach Tier 1 access and can power very low–load appliances, such as lighting and phone charging, for at least four hours per day. Only 17.4% off-grid solar households have a solution of 50 watts (or 200 watt-hours) and above, thus reaching Tier 2 or above.

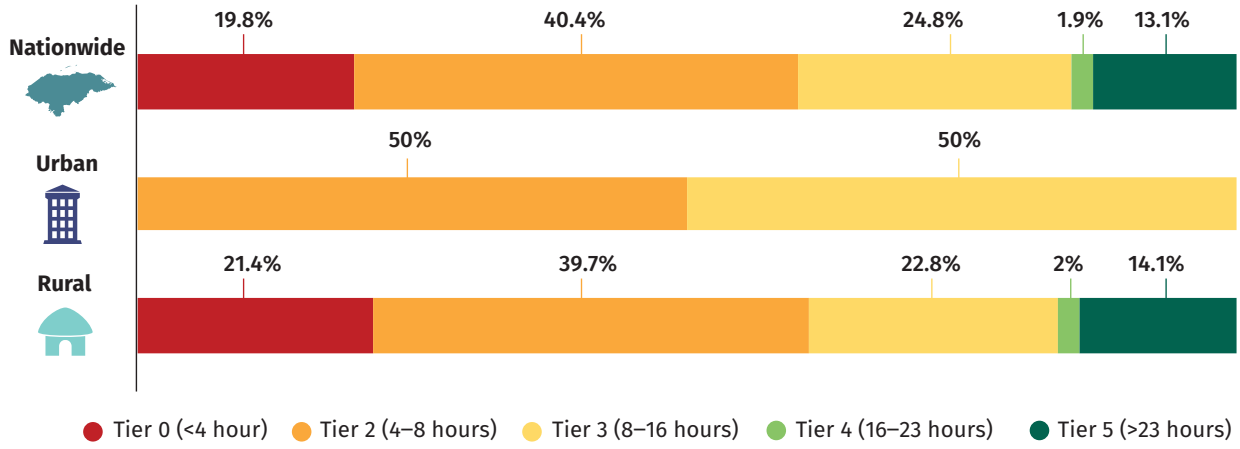
FIGURE 39 • **Distribution of off-grid solar households based on Capacity (nationwide)**



Note: Sample size = 149 households; only households using a solar device as their primary source of electricity.

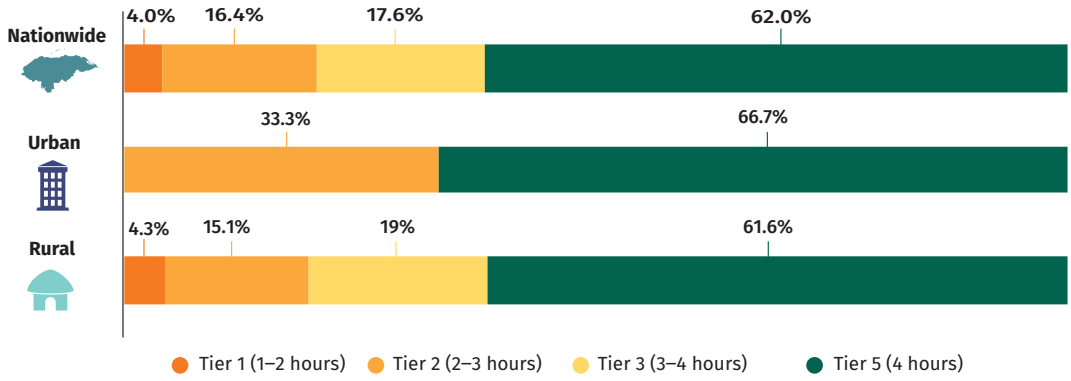
Among off-grid solar users, about 13% households receive more than 23 hours of electricity per day (Figure 40). This finding suggests that about 17% of solar households have a 50- to 199-watt solution (Tier 2 for Capacity) that receives power for more than 23 hours (Tier 5 for Availability). About a quarter of solar households receive electricity for 8 to 16 hours (Tier 3) and 40% for 4 to 8 hours (Tier 2). One in five of solar users receive electricity for less than four hours per day, suggesting that although most solar users can power only very low–load appliances with their systems, most can use electricity for 4 to 16 hours. Evening Availability is not an issue for 62% of solar users (Figure 41). This suggests that households receiving electricity for less than eight hours a day tend to suffer from poor Evening Availability as well.

FIGURE 40 • **Distribution of off-grid solar households based on Daily Availability (nationwide, urban/rural)**



Note: Sample size = 149 households; only households using a solar device as their primary source of electricity.

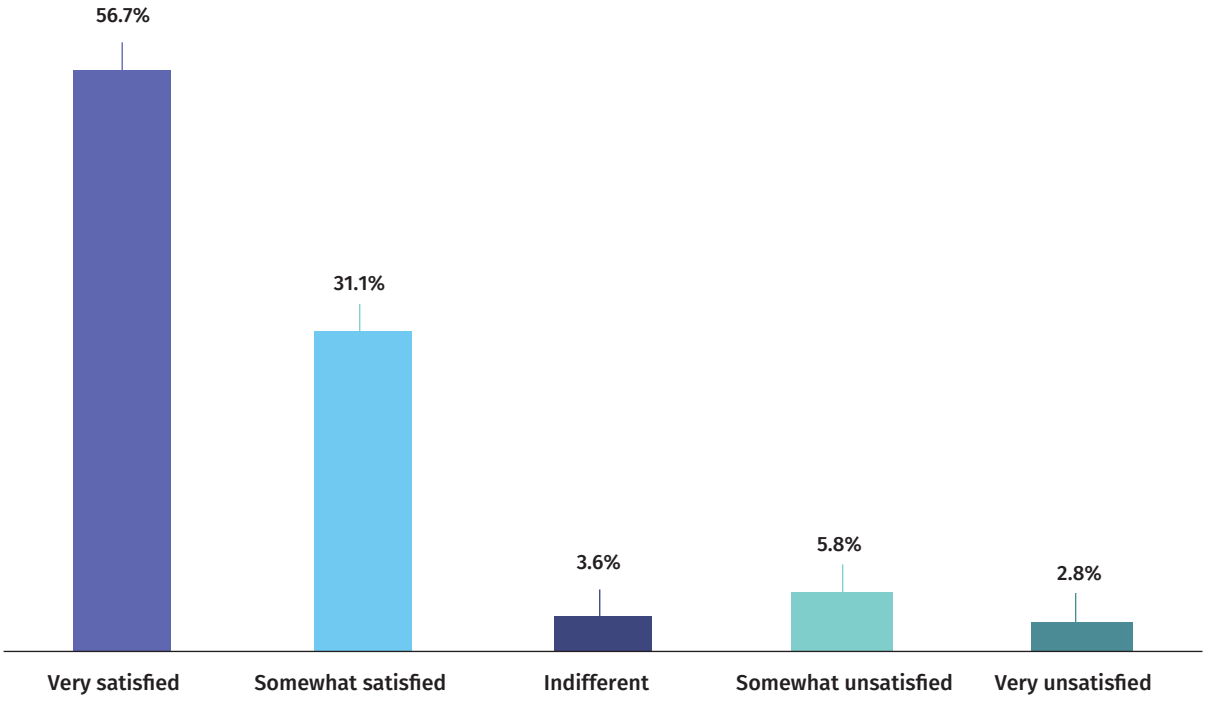
FIGURE 41 • **Distribution of off-grid solar households based on Evening Availability (nationwide, urban/rural)**



Note: Sample size = 149 households; only households using a solar device as their primary source of electricity.

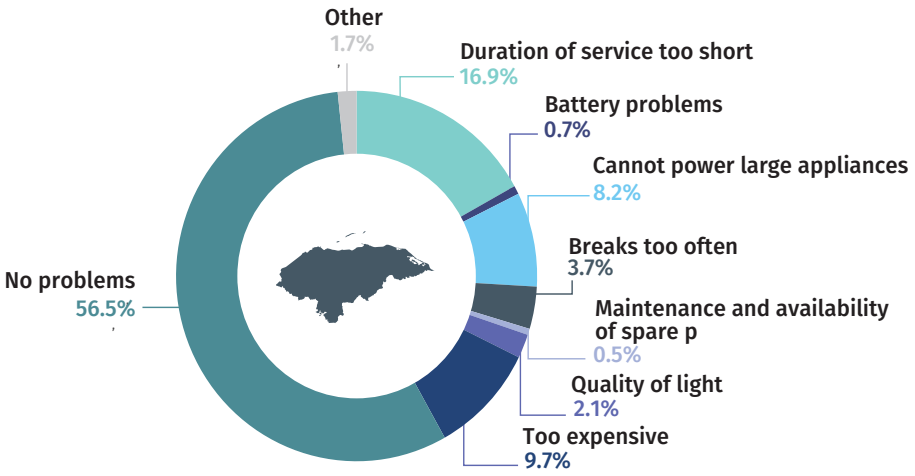
Among households that use a solar device, about 88% are satisfied with their solution (Figure 42), suggesting that even solar users in Tier 0 consider their solution satisfactory. More than half of the solar users reported no issues regarding their device (Figure 43). Almost 17% felt limited by the short duration of electricity. About 11.9% experience problems related to the maintenance (battery replacement): specifically, battery problems (9.6%), it breaks too often (3.7%), or maintenance and availability of spare parts (0.5%). About 8.2% complained that they could not power large appliances.

FIGURE 42 • **Satisfaction levels of solar device users (nationwide)**



Note: Sample size = 149 households; only households using a solar device as their primary or secondary source of electricity.

FIGURE 43 • **Main issues for households using solar solutions (nationwide)**



Note: Sample size = 149 households; only households using a solar device as their primary or secondary source of electricity.

POLICY RECOMMENDATIONS

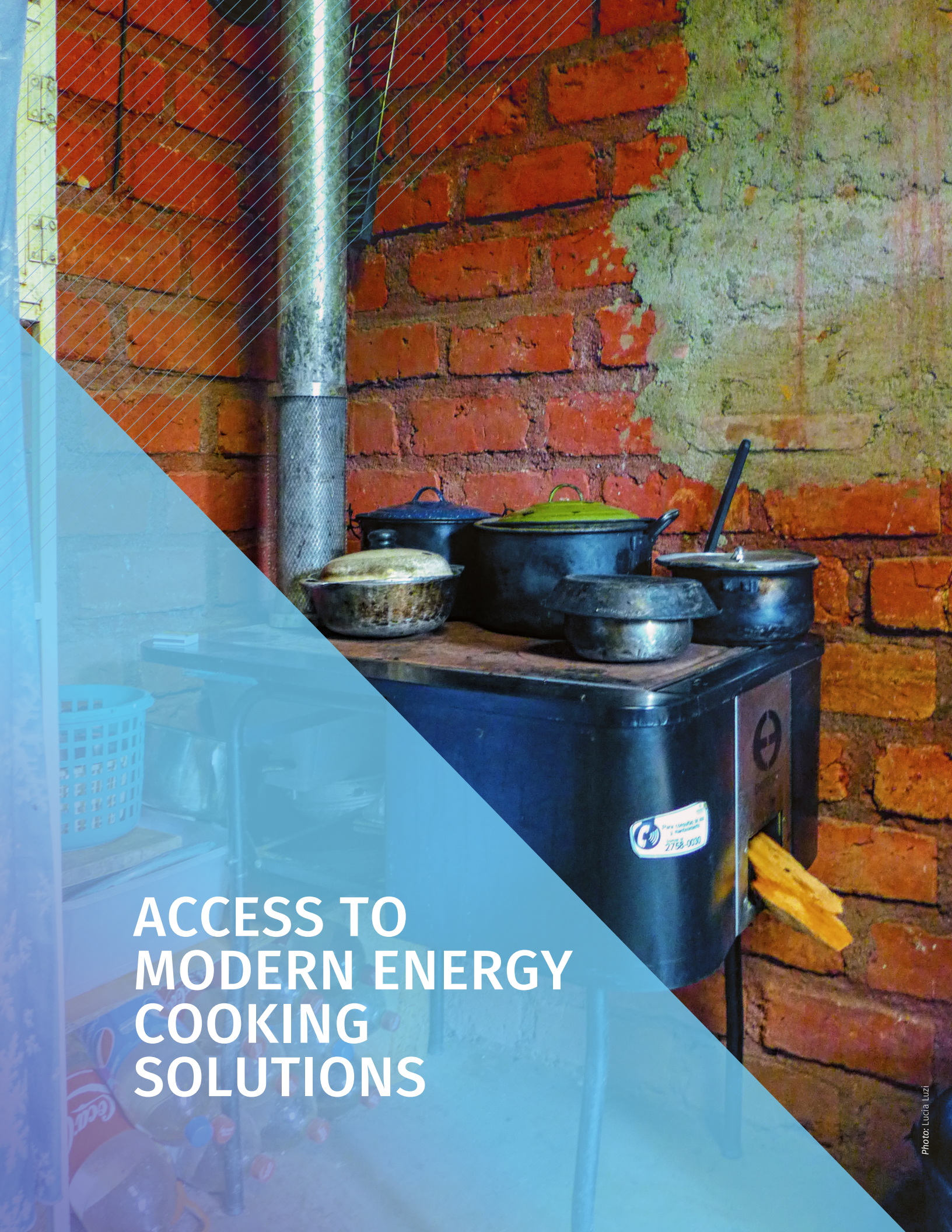
In Honduras, 84% of the households are connected to the national grid. Among them, 46.4% are in Tiers 3 and 4 and 49.7% are in Tier 5. Improvements in Quality (reducing voltage fluctuation), Reliability (reducing the number and duration of outages), and even Formality (reducing informal connection) of the grid can shift households in Tiers 3 and 4 to Tier 5.

Nationwide, only 4.2% of households use off-grid solutions, and most use solar devices. Most off-grid solution users are concentrated in Tiers 0 and 1 (86.1%) for access to electricity. Capacity is the main constraint solar users face. Thus, dissemination of larger off-grid solar systems could shift them into higher tiers.

In Honduras, 13.5% of households are in Tier 0 for access to electricity. Overall, 87.1% of the Tier 0 households have no access to any electricity source, 8.9% use solar solutions, and the remaining 4% have a grid connection. Moving these households with no access to any electricity to higher tiers would require the provision of either grid or off-grid access. The following are policy recommendations to provide electricity to those without any:

- ***Extend the grid.*** Connecting households to the national grid could shift them to Tier 3 or above. Connecting households in nongrid-electrified areas would require grid extensions and possibly financing schemes to make grid connections affordable. Connecting households "under the grid"—directly beneath existing grid infrastructure—and potentially increasing grid electrification by over 7 percentage points, would require additional financing schemes and payment plans over time to reduce upfront cost and make connections affordable.

- ***Provide off-grid access.*** Off-grid solar products may often be a more feasible solution for households that lack local grid infrastructure. Although Honduran households have started using solar devices only in recent years, most seem to be satisfied with the current service. Further, the cost of purchase of a low-capacity, off-grid solution is lower than the grid connection fee. Thus, providing off-grid access through solar devices of at least 3 watts (or 12 watt-hours) can move Tier 0 households to higher tiers (most likely Tiers 1 or 2) for access to electricity. Strengthening quality assurance systems coupled with microfinance and leasing opportunities could increase the adoption of solar devices. Consumer awareness programs could help potential customers choose products of adequate quality and use them more sustainably.



ACCESS TO MODERN ENERGY COOKING SOLUTIONS

Photo: Lucia Luzi

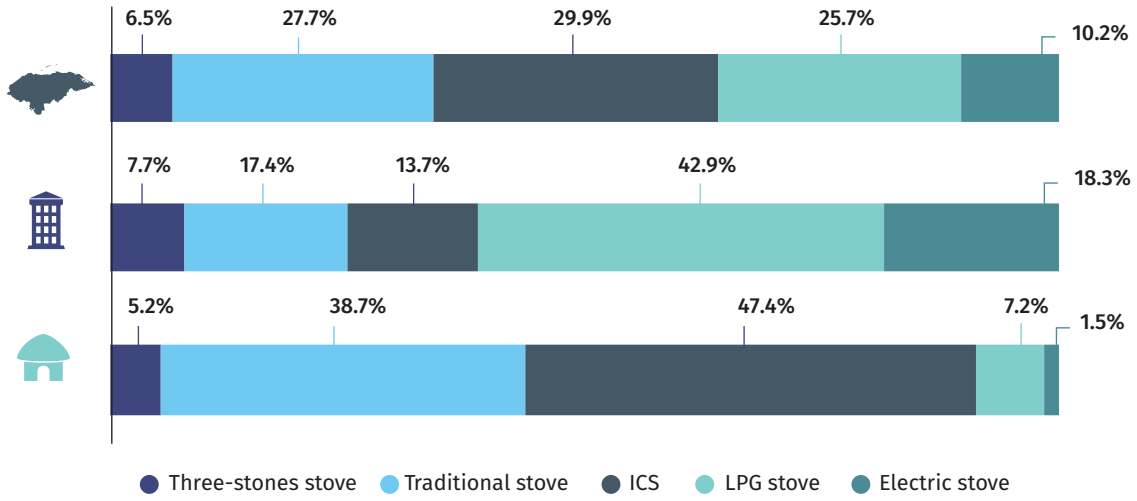
ASSESSING ACCESS TO MODERN ENERGY COOKING SOLUTIONS

TECHNOLOGIES

In Honduras, most households use a biomass stove (including three-stone stoves, traditional stoves, and improved biomass cookstove [ICS]) as their primary means of cooking.[20] Most households use either ICSs (29.9%) or traditional stoves (27.7%), and 6.5% of the households use three-stone stoves (Figure 44).[21] The penetration of clean fuel stove (LPG and electric stoves) used as primary stove in the country is fairly high (35.9% in total): 25.7% of the households use liquefied petroleum gas (LPG) stoves and 10.2% use an electric stove.[22]

Urban and rural households have different cooking patterns. Urban households cook predominantly with LPG stoves (42.9%) and electric stoves (18.3%), while 17.4% use traditional stoves and 13.7% use ICSs. In the rural areas, as expected, biomass stoves are prevalent: ICS is predominant (47.4%), followed by traditional stoves (38.7%) and three-stone stoves (5.2%). The penetration of LPG and electric stoves is limited in rural areas (7.2% and 1.5%, respectively).

FIGURE 44 • **Distribution of primary cookstove used (nationwide, urban/rural)**



Note: Sample size = 2,750 households. Biomass stoves include three-stone stoves, traditional stoves, and ICSs (including RS gasifier). Clean fuel stoves include LPG stoves, and electric stoves.

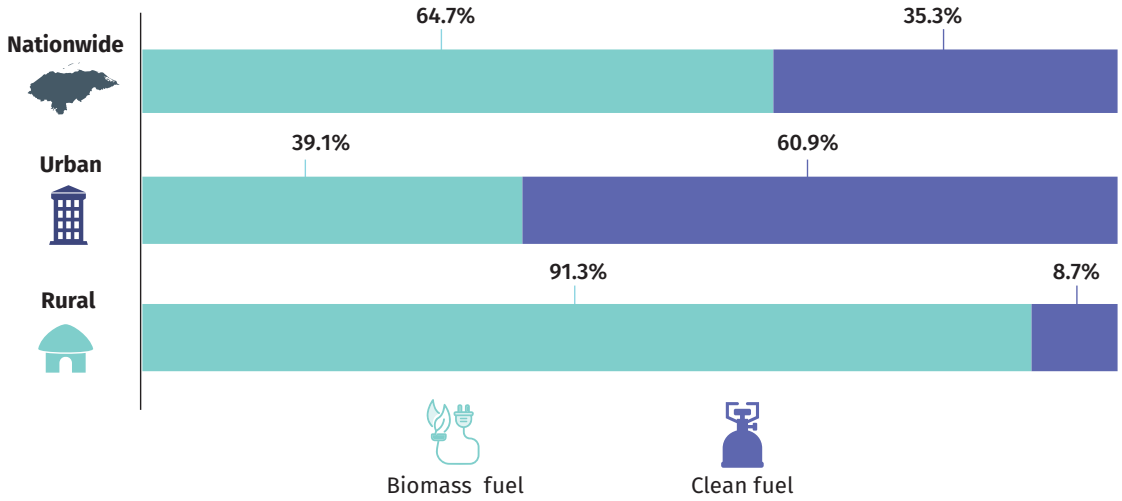
[20] Primary cookstove is defined as the one used most of the time in the household. Households were asked to identify their primary cookstove if they use multiple stoves. From the MTF perspective, a household must have only one primary cookstove.

[21] Three households in the survey (0.3% of the households) report that their primary stove is a rocket stove (RS) gasifier, a type of ICS. In this section, RS gasifier is included in the ICS percentage.

[22] For more details about each type of cookstove, see Annex 3.

More than half of the Honduran households (64.7%) still heavily rely on biomass as their primary cooking fuel to meet their cooking needs, with firewood as the main component. Clean fuel is more widely used as primary cooking fuel by households in urban areas (60.9%) than in rural areas (8.7%) (Figure 45).

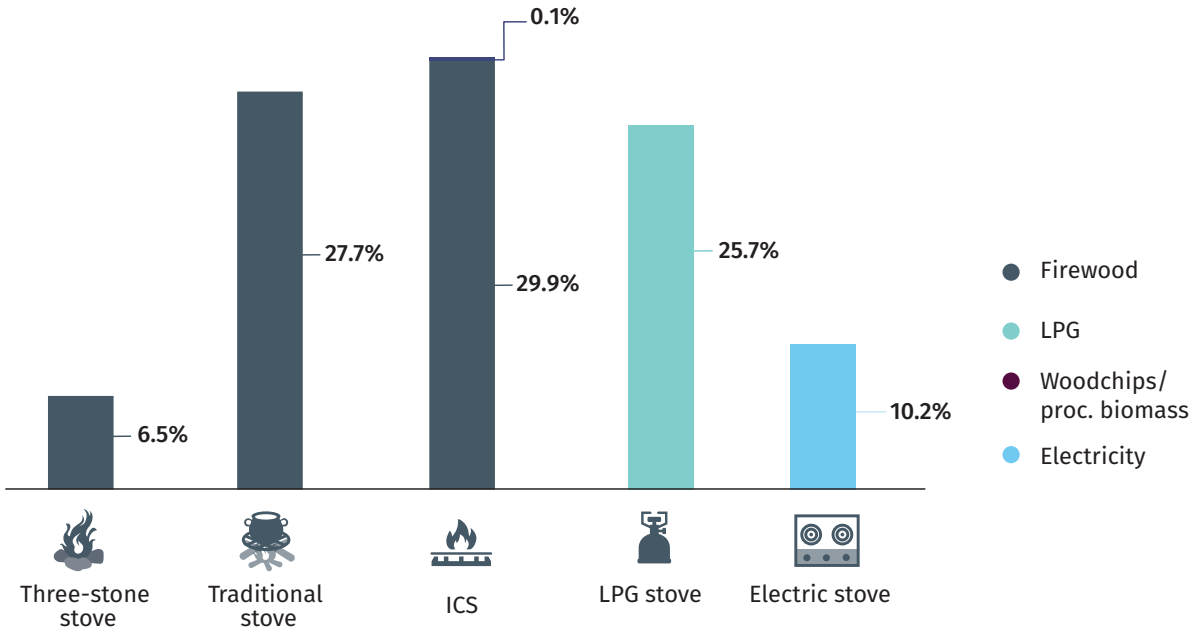
FIGURE 45 • **Type of fuel usage by sector (nationwide, urban/rural)**



Note: Sample size = 2,699 households. Biomass fuel includes firewood, charcoal, crop residue, plants biomass, sawdust, and woodchips.

Firewood is the most widely used source of cooking fuel: about 64% of the households nationwide rely on it (Figure 46). Of the households that cook with biomass stoves, 6.5% use a three-stone stove as their primary cooking solution, 27.7% use a traditional stove, and 30% use an ICS, almost totally burning firewood. Clean fuel stoves (mainly stoves using LPG) are the primary cooking solution of 35.9% of households.

FIGURE 46 • **Distribution of cookstoves and fuel used (nationwide)**

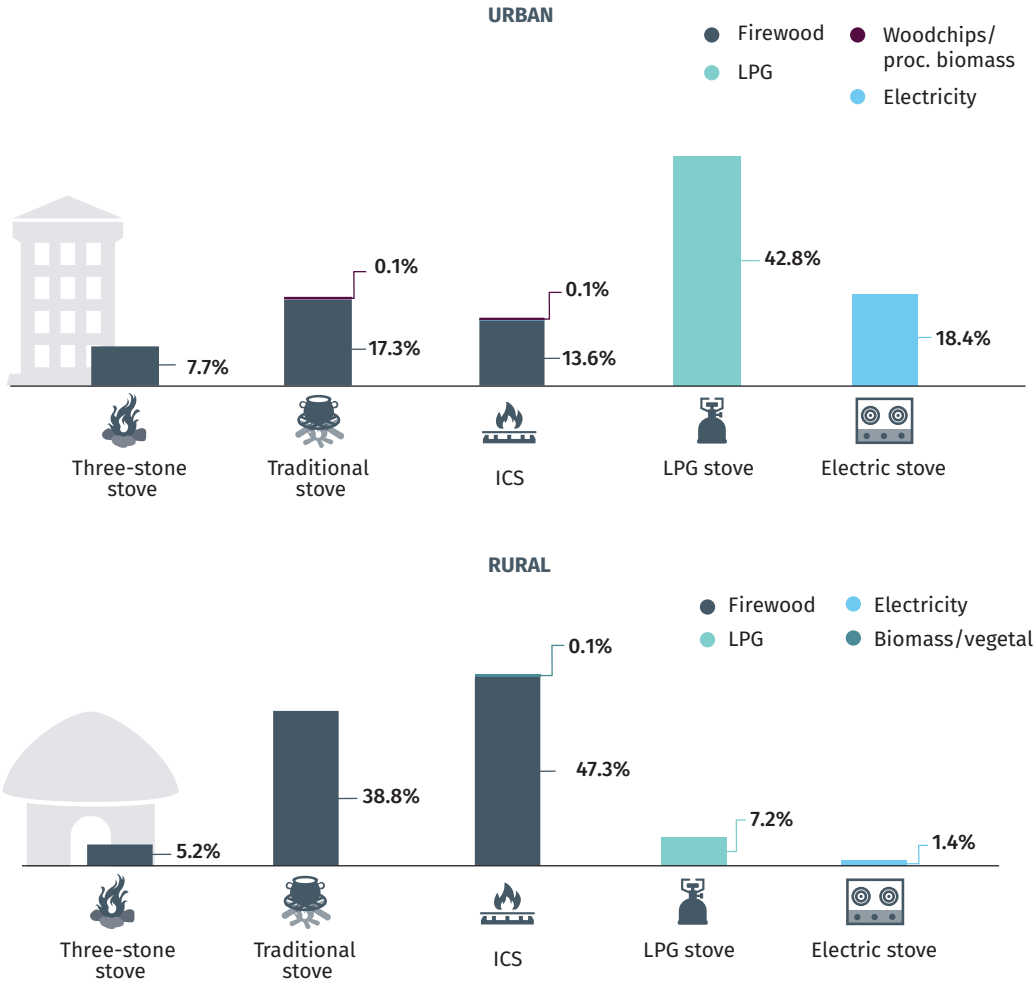


Note: Sample size = 2,750 households.

Using firewood as a primary cooking fuel is more prevalent among rural households: 91.3% of rural households use firewood for cooking compared with 38.6% of the urban (Figure 47). In urban areas, half of the households use either LPG (42.8%) or electricity (18.4%) as their primary cooking fuel, while only 7.2% and 1.4% of rural households do, respectively.

It is likely that some households adopt multiple fuels to meet cooking needs, a practice known as "fuel stacking,"[23]—often viewed as a household response to fuel scarcity and price fluctuation. In addition, individual preferences play a role in the choice of fuels. For example, it is often heard that certain foods taste better when cooked with firewood. Since biomass fuels can vary in energy content and conversion efficiency, fuel stacking can be an issue between firewood and nonfirewood biomass fuels.

FIGURE 47 • **Distribution of cookstoves and fuel used (urban/rural)**



Note: Sample size = 2,750 households.

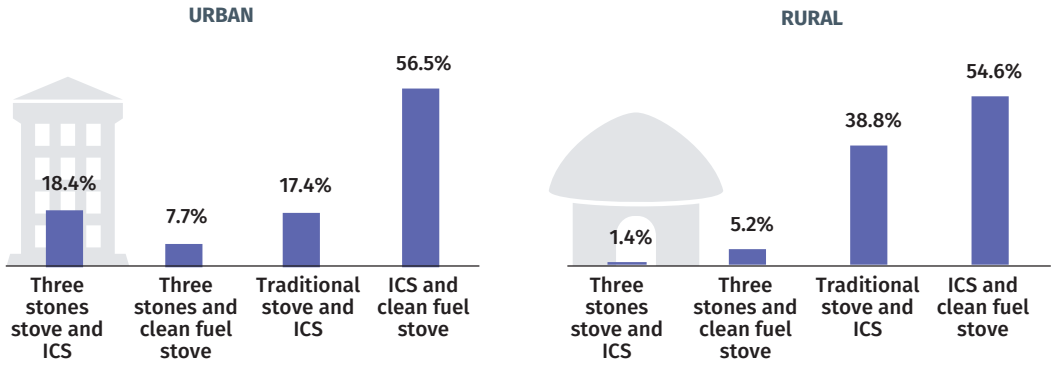
[23] For additional explanation on the origins and reasons behind fuel stacking, please refer to Bhatia and Angelou (2015, 46).

Stove stacking

Stove stacking (use of multiple stove types) is common because one stove often does not satisfy the cooking needs of the households. Stove stacking may also happen when households use certain stoves for specific purposes. For example, some households use LPG stoves only for light cooking, such as boiling water to make tea or cooking snacks, and use traditional stoves to cook main meals. The choice and mix of stoves often depend on cultural practice that cannot be easily changed regardless of the availability of alternate options. The issues of Availability and Affordability of clean fuels could be important reasons for stacking, too. Further, if electric Capacity is low and there are constant interruptions in the service, electric stoves will probably not fulfill all cooking needs. Stove stacking within clean cookstoves (for example, using LPG stoves and electric stoves) is not an issue. However, stacking clean cookstoves with biomass stoves is a cause for concern because it negates the benefits of clean cooking in terms of health benefits and efficiency.

Most stove stacking involves a clean fuel stove and an ICS (55.6% of the households), or a traditional cookstove and an ICS (27.7%). A small percentage of household use a three-stone stove and an ICS (10.2%), or a three-stone stove and a clean fuel stove (6.5%). Urban and rural areas have different stove stacking patterns: 17.4% and 38.8% of urban and rural households, respectively, use a traditional cookstove and an ICS; 18.4% and 1.4% of urban and rural households, respectively, use a three-stone stove and an ICS. All rural and urban households that use three-stone stoves stack it with clean fuels (Figure 48).

FIGURE 48 • **Two-stove type users (urban/rural)**

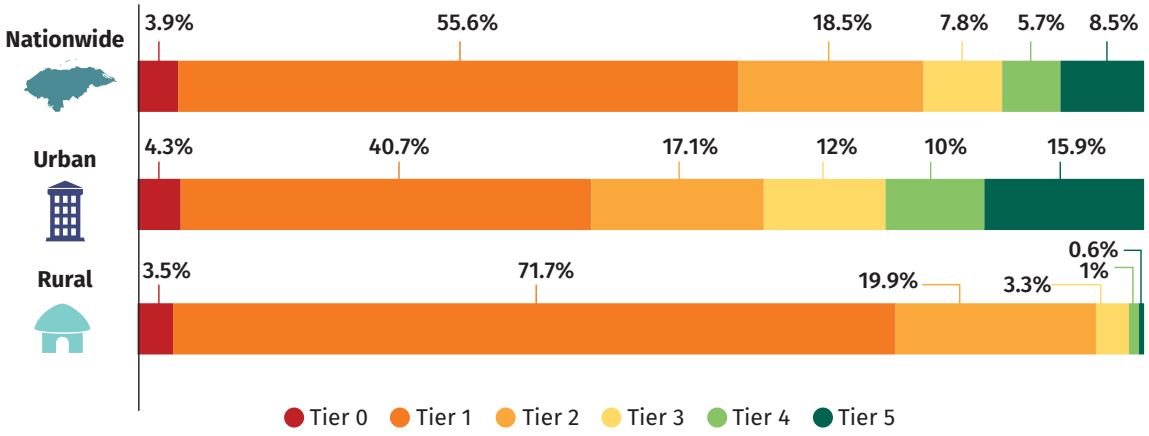


Note: Sample size = 2,750 households nationwide.

MTF TIERS

In Honduras, most households are concentrated in Tier 1 (55.6%) due to the high share of traditional stoves and ICSs (Figure 49). There is a wide rural-urban gap. A higher percentage of rural households (71.7%) are in Tier 1 compared to urban households (40.7%). By contrast, more urban households fall in higher tiers for access to modern cooking solutions. Of urban households, 22% are in Tiers 3 and 4 and almost 16% in Tier 5, compared with 4.3% of rural households in Tiers 3 and 4 and 0.6% in Tier 5. This is mainly because clean fuel stoves are mostly used in urban areas. However, using a clean fuel stove does not automatically categorize these households into higher tiers. For instance, about 61% of urban households and about 9% of rural households use a clean fuel stove as their primary stove, but only about 26% of urban households and 1.6% of rural households are in Tiers 4 or 5 for access to modern energy cooking solutions.

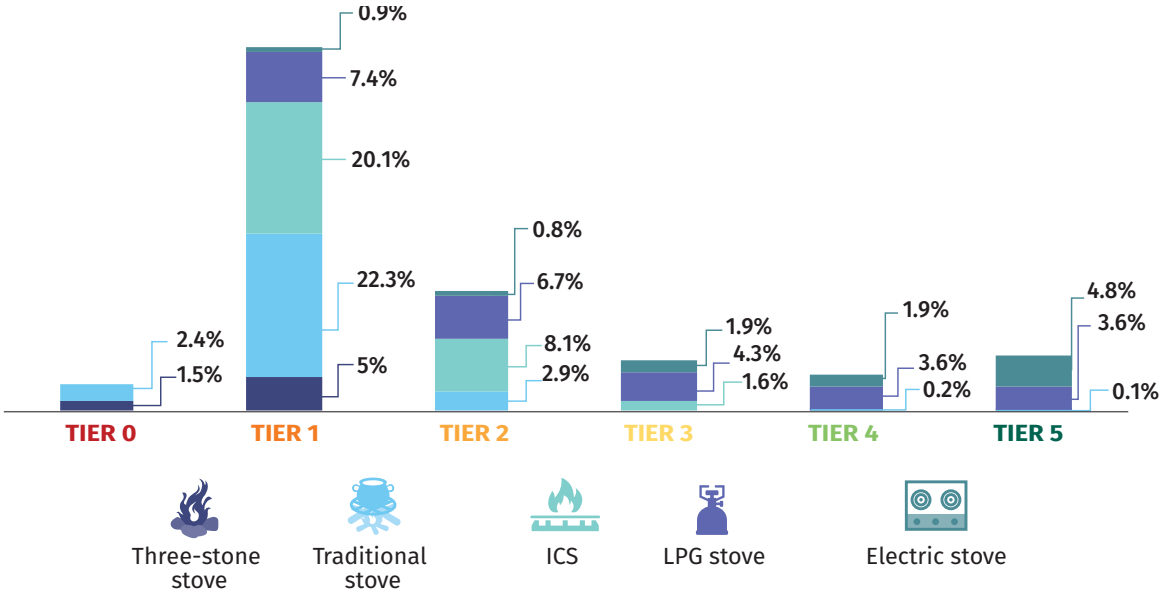
FIGURE 49 • **MTF tier distribution: access to modern energy cooking solutions (nationwide, urban/rural)**



Note: Sample size = 2,750 households.

Households that primarily use traditional stoves and ICSs are concentrated in Tiers 1 and 2, while almost all households in Tiers 4 and 5 use either electricity (6.7%) or LPG (6.2%) as their primary fuel source (Figure 50). Even though households whose primary stove is either LPG stoves or electric stoves are found in lower tiers, most use traditional stoves and ICSs as their secondary stove. Although according to the MTF analysis Convenience seems to be why clean fuel stoves (LPG stoves and electric stoves) are in lower aggregate tiers, the underlying reason is that some households opt for multiple stoves. The practice of stove stacking leads some households to use both clean fuel stoves and biomass stoves, the latter requiring more fuel collection and preparation time than the former. Therefore, while the adoption of clean fuel stove is a necessary condition for reaching higher tiers for access to modern energy cooking solutions, it is not a sufficient one because of other factors that may determine the state of cooking solutions. The underlying determining factors are clarified in the next section, in which the attributes are examined.

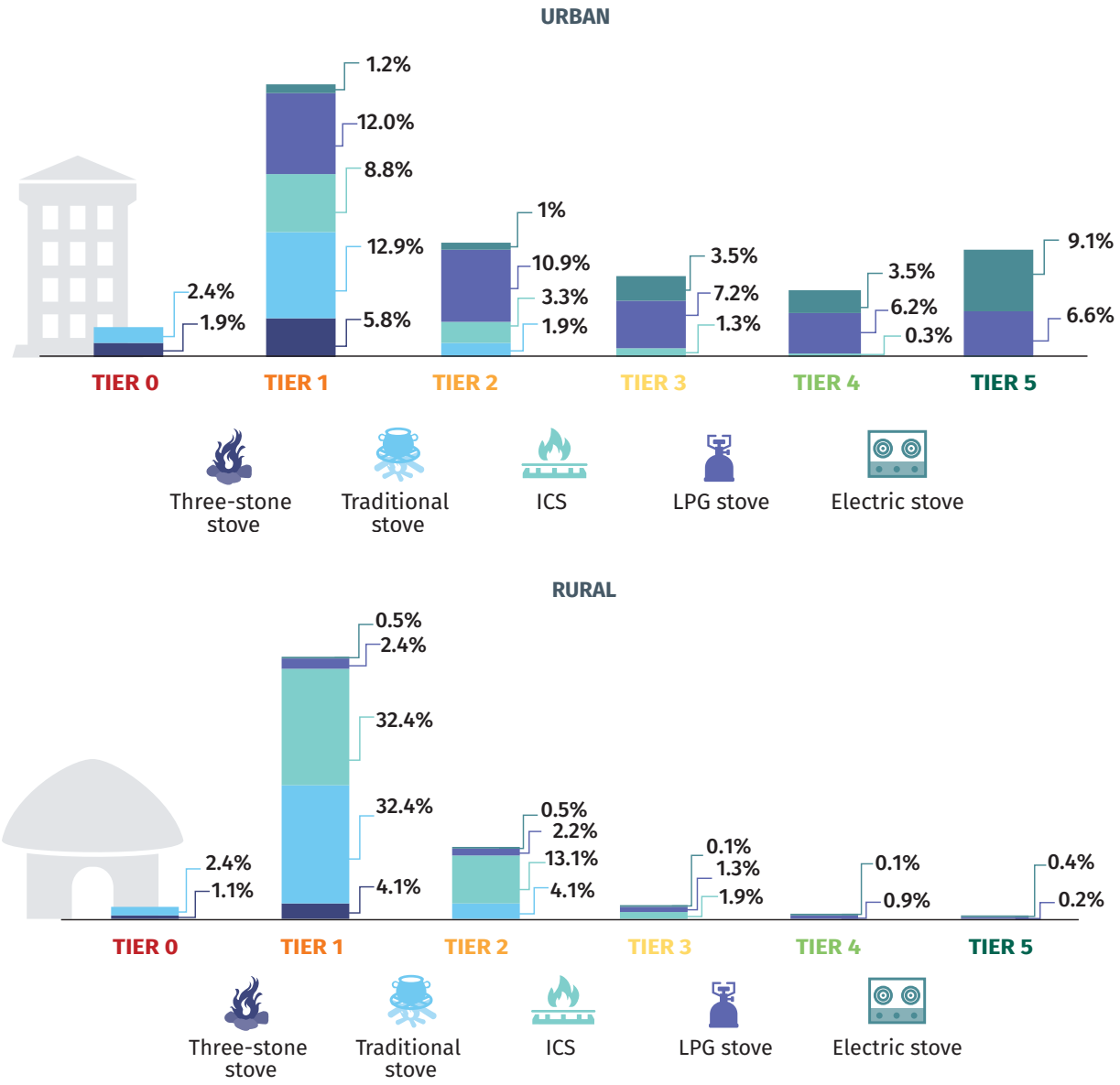
FIGURE 50 • **MTF tier distribution by primary stove type (nationwide)**



Note: Sample size = 2,750 households.

The large gap in access to modern cooking solutions between urban and rural areas can be explained by different use of primary cooking solutions, because a larger portion of rural households than urban households use traditional stoves or ICSs (Figure 51). Urban households tend to be in higher tiers mainly because clean fuel stoves are mostly used in these areas; however, using a clean fuel stove does not automatically categorize these households into Tiers 4 or 5. For instance, about 61.2% of the urban households use a clean fuel stove (electric and LPG stoves) as their primary stove, but only 25.4% of urban households are in Tiers 4 or 5 for access to modern energy cooking solutions (9.7% in Tier 4 and 15.7% in Tier 5). In contrast, 8.6% of rural households use a clean fuel stove as their primary stove, and only 1.6% of the rural households are in Tiers 4 or 5 (1% in Tier 4 and 0.6% in Tier 5). This is mainly because most Honduran households—especially urban—use LPG stoves with a biomass stove.

FIGURE 51 • **MTF tier distribution by primary stove type (urban/rural)**



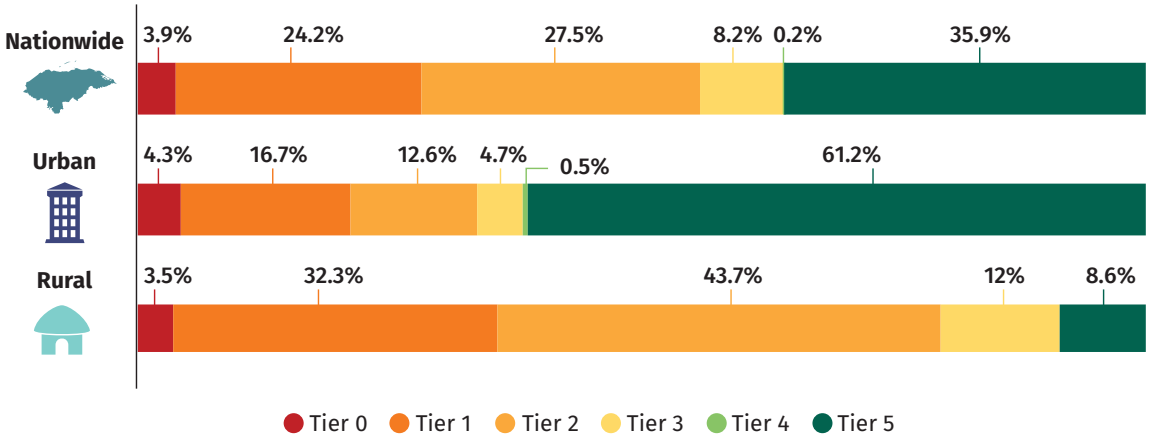
Note: Sample size = 2,750 households.

MTF ATTRIBUTES[24]

Cooking Exposure

Nationwide, 35.9% of the households are in Tier 5 for the Cooking Exposure attribute, which represents an estimate of personal exposure during cooking activities based on the emissions of cooking and the ventilation, due to the use of clean fuel stoves. In urban areas, the share of the households in Tier 5 goes up to 61.2%, while in rural areas only 8.6% are in the highest tier. About 28% of the households are in Tiers 0 and 1 for Cooking Exposure due to the use of traditional stoves (open and enclosed fires) with poor ventilation (Figure 52).

FIGURE 52 • **Distribution of households based on Cooking Exposure (nationwide, urban/rural)**



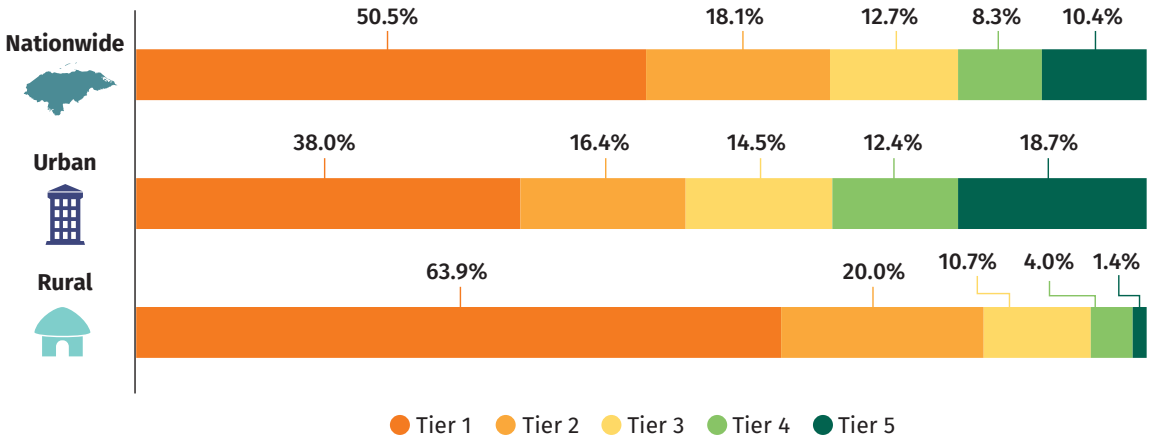
Note: Sample size = 2,737 households.

Convenience

The Convenience attribute has two parts: (i) the amount of time a household spends acquiring and preparing fuel each week; (ii) the amount of time a household spends preparing a stove for cooking before each meal. Nationwide, 50.5% of households spend more than seven hours per week collecting and preparing fuel, or at least 15 minutes preparing a stove before each meal (Figure 53). Households in lower convenience tiers primarily use biomass stoves, which require more effort and are less efficient than clean fuel stoves.

[24] Cookstove Efficiency is not included in this analysis as there was limited information from testing facilities on the efficiency level of the stoves and from the field data to identify the stoves.

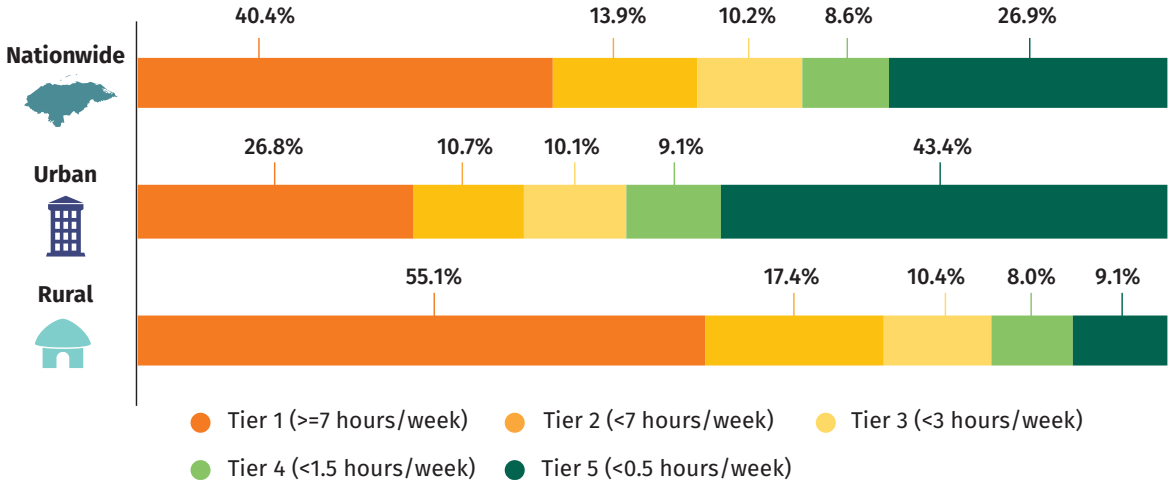
FIGURE 53 • **Distribution of households based on total Convenience (nationwide, urban/rural)**



Note: Sample size = 2,750 households.

Nationwide, 40.4% of the households spend more than seven hours per week acquiring and preparing fuel, while 26.9% spend less than 30 minutes (Figure 54). There are different patterns between urban and rural areas. In rural areas, 94.6% households spend more than one-and-a-half hours per week acquiring and preparing fuel; in urban areas, 31% of households spend less than one-and-a-half hours per week.

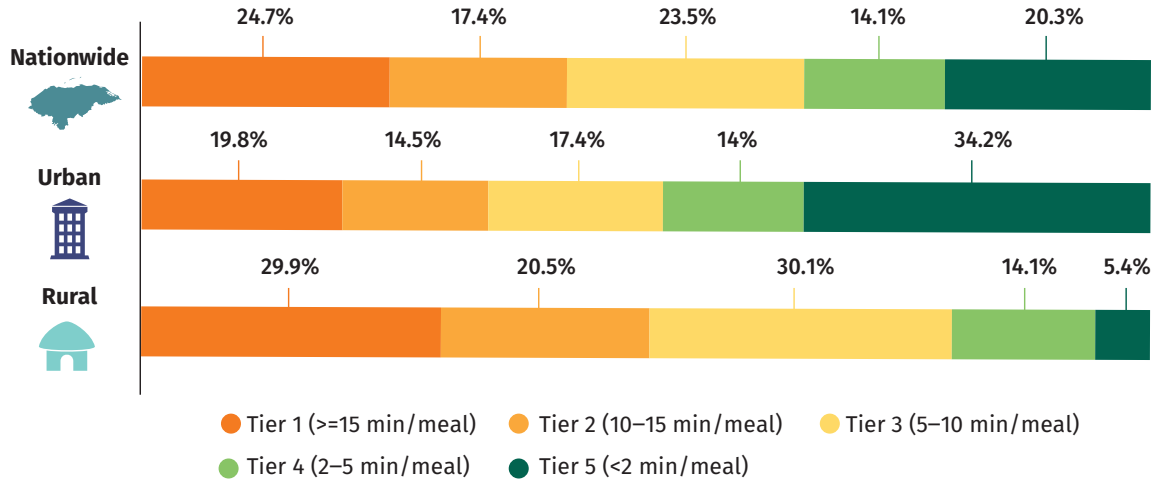
FIGURE 54 • **Distribution of households based on fuel Convenience (time spent for fuel collection and preparation, nationwide, urban/rural)**



Note: Sample size = 2,737 households.

About 65.6% of the households spend more than five minutes to prepare their stove before each meal (Figure 55). Only one in five households spends less than two minutes for each stove preparation. In urban areas, the share reaches one in three, while in rural areas it falls to 5.4%.

FIGURE 55 • **Distribution of households based on stove Convenience (time spent for stove preparation), (nationwide, urban/rural)**

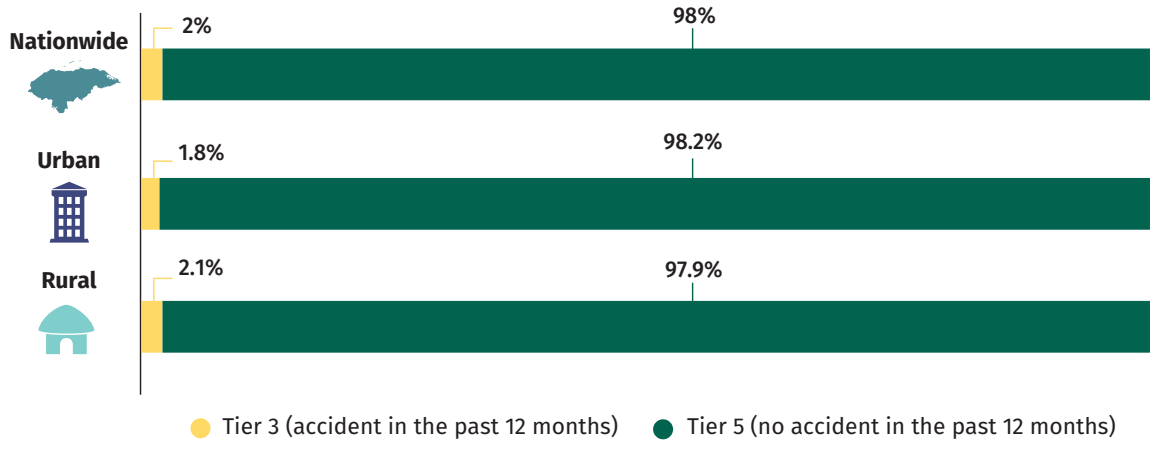


Note: Sample size = 2,737 households.

Safety of Primary Cookstove

The attribute of Safety of Primary Cookstove is a yes-no attribute, determined by the incidence of serious injuries from the use of the main cookstove for one year preceding the survey. Households are assigned Tier 3 if they report any such incidents, and Tier 5, otherwise. Most households did not recall a major injury over the last 12 months (Figure 56). Only 2% of households nationwide reported serious injuries, including permanent health damage; burns, fire, or poisoning; or even death of a household member within the past year, resulting from the use of their primary cooking device or fuel.

FIGURE 56 • **Distribution of households based on Safety of Primary Cookstove (nationwide, urban/rural)**

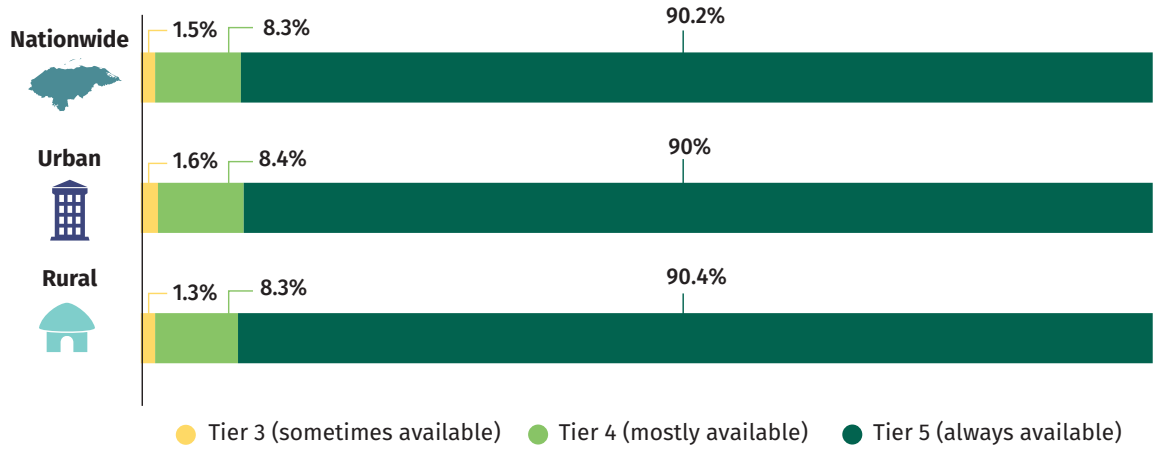


Note: Sample size = 2,737 households.

Fuel Availability

This attribute is determined by the availability of the main fuel. A household is assigned to Tier 3 if the primary fuel is not available at least 80% of the time, to Tier 4 if it is available at least 80% but not 100% of the time, and to Tier 5 if it is always available. Fuel Availability is not a major issue for households. About 1 in 10 households reported that fuel was not always available (Figure 57). Fuel was mostly available for most households, while only 1.5% of households reported that fuel was only sometimes available. No significant difference in this respect was experienced by rural or urban households.

FIGURE 57 • **Distribution of households based on Fuel Availability (nationwide, urban/rural)**

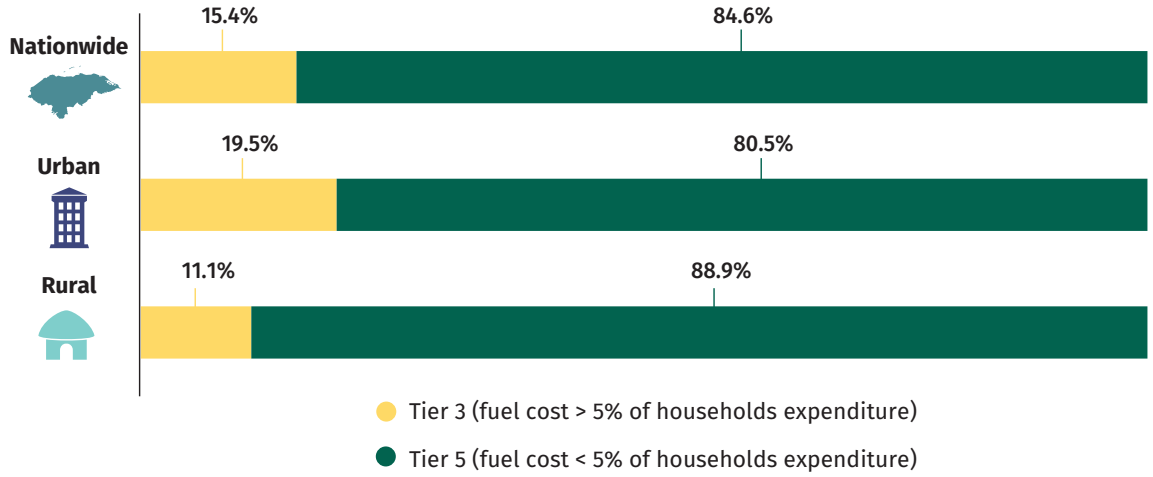


Note: Sample size = 2,737 households.

Affordability

Affordability is a binary (yes-no) attribute measured by the levelized cost of the cooking solution (both stove and fuel). A household is assigned Tier 5 if the cost is less than 5% of its annual general expenditure, and Tier 3, otherwise. Assessing the cost of the stove, which is subject to depreciation, is not straightforward. This analysis considers only the cost of fuel. The cost of the fuel refers to how much the household has spent on a fuel in a typical month. In the MTF context, a type of fuel would not be considered as affordable if the average expenditure of the household on that fuel would be less than 5% of the total monthly expenditure on fuels of the household. Nationwide, 84.6% of households spend less than 5% of their total household expenditure on cooking fuel (Figure 58). Fuel is considered unaffordable for about one in five urban households, compared with only one in ten rural households. This gap is because urban households tend to use LPG stoves more than their rural counterparts do.

FIGURE 58 • **Distribution of households based on Affordability (nationwide, urban/rural)**



Note: Sample size = 2,737 households.

IMPROVING ACCESS TO MODERN COOKING SOLUTIONS

The objective of improving access to modern energy cooking solutions should be to facilitate access among all households to cooking solutions that are clean, convenient, efficient, affordable, safe, and available. An increase in the rate of access of clean fuel stoves could move households to the highest tier. In addition to clean fuel stoves, the promotion of ICSs could help shift households—particularly in Tier 0—into higher tiers.

The two main obstacles keeping households from moving to higher tiers are Cooking Exposure and Convenience, both related to the continued use of biomass cookstoves. The breakdown of aggregate tier by primary stove type (Figure 50) indicates that lower tier households use mostly biomass stoves, which are major factors leading to higher emissions, and consequently, higher exposure to indoor air pollution. Higher tier households, on the other hand, use clean stoves only. For higher tier households, mainly the lack of Convenience (and, moderately, Affordability) of the primary fuel may likely stem from supply chain issues. Policy recommendation can target all households using biomass-based stoves.

INCREASING PENETRATION OF CLEAN FUEL STOVES

Most households in Honduras rely on an ICS and on traditional stove (biomass-based cooking). Promoting clean fuel stoves, such as electric stoves or LPG stoves, among these households is an obvious option. However, promoting clean fuel stoves is a complex transformational change challenge and requires good insights into country-specific conditions and potentials. The constraints that may prevent households from switching over to clean fuels can be identified both in the supply side and the demand side. From the, the constraint may be related to the fact that, differently from most urban households in the country, without supporting policies, several rural households will not have the opportunity to switch to using modern cooking energy services because is not likely to find clean fuels given that, for instance, they do not have any LPG network available (supply side). Furthermore, it is possible that even if these rural households have access to such infrastructure, they cannot afford to pay for the clean fuel (demand side).[25]

Examining the challenges that clean fuel stove users face to try to avoid these problems in the future could make the promotion process more efficient and successful. MTF data show that all the clean fuel stoves are in Tier 5 for both Cookstove Exposure and Convenience.

Possible constraints to promoting clean fuel stoves include the following. Overall, 4.8% of households that primarily use a traditional stove or an ICS do not have grid connection.

For households connected to the national grid, only 32.3% use an electric stove or LPG stove as their primary stove; urging them to mainly cook with electric or LPG stoves is going to shift them to higher tiers. Specifically, electricity penetration rates are very high—even though only a few households (10.2%) use electric stoves—making this a feasible solution.

INCREASING ADOPTION OF CLEAN COOKING SOLUTIONS

While promoting clean fuel stoves is a long-term goal, a short-term solution would be to increase adoption of improved biomass cookstoves as primary cooking solutions, particularly in rural areas. As mentioned, 34.1% of Honduran households cook with a three-stone stove or a traditional stove (Figure 44). Some of those (6.7%) do not have grid connection and are overrepresented in the lower quintiles. Thus, improved biomass cookstoves may be the most feasible solution to move such households into higher tiers (most likely Tiers 1 through 3). Improved cookstoves result in minimal disruption in cooking practices, and households can rely on existing fuel. Moreover, since an ICS is expected to consume less fuel than traditional stoves, dependence on fuel will be less. Thus, adoption rates can increase faster than for clean fuel stoves.

The ICS is not more common in the country for several reasons. It is more expensive than traditional stoves. Thus, more campaigning and sensitization about the ICS's potential benefits are needed toward potential buyers concerned about the price. Lack of proper monitoring and after sales service can represent a barrier to increase the use of the ICS. Support for market development as well to encourage more players to enter the market and provide more options to households.

While the ICS is certainly better than traditional stoves, MTF results show that households using it are still in low tiers. Eventually, all households need to make a complete switch to clean cooking

[25] As indicated in a recent study (Pachauri et al., 2018), given that for a considerable amount of rural households in Honduras moving from biomass to clean fuel may be out of reach in the short term, a cost-effective interim solution might be to combine stove grant policies with a considerable scale-up of improved cook stoves."

solutions, which result in high tiers. Based on the MTF results for Honduras, it would be justified to make a strong case for electric cooking.

Besides considering stove design and fuels, the cooking solution must consider kitchen design, which is often ignored. Kitchen design is an essential component of the attribute of Cooking Exposure, and contributes directly to the MTF. While increasing kitchen volume may not be feasible, improving ventilation structure should be encouraged through marketing and demonstration.

POLICY RECOMMENDATIONS

In Honduras, 57.6% of households primarily use an ICS or traditional stoves. Cooking Exposure (personal exposure to pollutants from cooking activities) and Convenience (the amount of time a household spends collecting or purchasing fuel and preparing the fuel and their stove for cooking) are the main constraints for these households in moving up the tiers. To shift these households to higher tiers, switching from biomass-based (solid fuel) cooking to clean cooking solutions would be critical.

Promote clean fuel stoves. For households in Tiers 0 through 2 (78%), the policy recommendation would be to promote clean fuel stoves, such as LPG and electric stoves, if these households can afford it. For those households in Tiers 3 and 4 (13.5%), households using both biomass and clean fuel stoves cannot maximize the benefit of using clean fuel stoves.

Households that primarily use clean fuel stoves face challenges from Convenience and, moderately, Affordability (the ability of the household to pay for both the cookstove and fuel). Addressing the high cost and the time spent collecting or purchasing fuel can shift these households to the highest tier for access to modern energy cooking solutions. Since almost 16% of biomass stove users are not connected to the national grid, a more feasible solution is to promote improved or advanced biomass stoves.

Promote improved or advanced biomass stoves. Cooking Exposure issues prevent 39% of the households from reaching higher tiers, and about 50% of households are constrained from reaching higher tiers by Convenience issues. More campaigning and sensitization are needed toward households relying on two stoves (for example, one clean fuel and one traditional) to alleviate the cost reservations of potential users.

Promoting clean fuel stoves is a long-term goal; a short-term solution would be to increase adoption of improved biomass cookstoves as primary cooking solutions. Moreover, since ICS is expected to consume less fuel than traditional stoves, households could spend less time and money to acquire cooking fuels. Thus, adoption rates can increase faster than for clean fuel stoves.

As for electric cooking solutions, to increase the adoption of an ICS, the issue of the high upfront cost should be addressed. Since households that use three-stone or traditional stoves tend to be in lower-income quintiles, offering installment plans may increase adoption of the ICS. Enhancing public awareness on the benefits of using improved biomass stoves rather than three-stone or traditional stoves is likewise important.

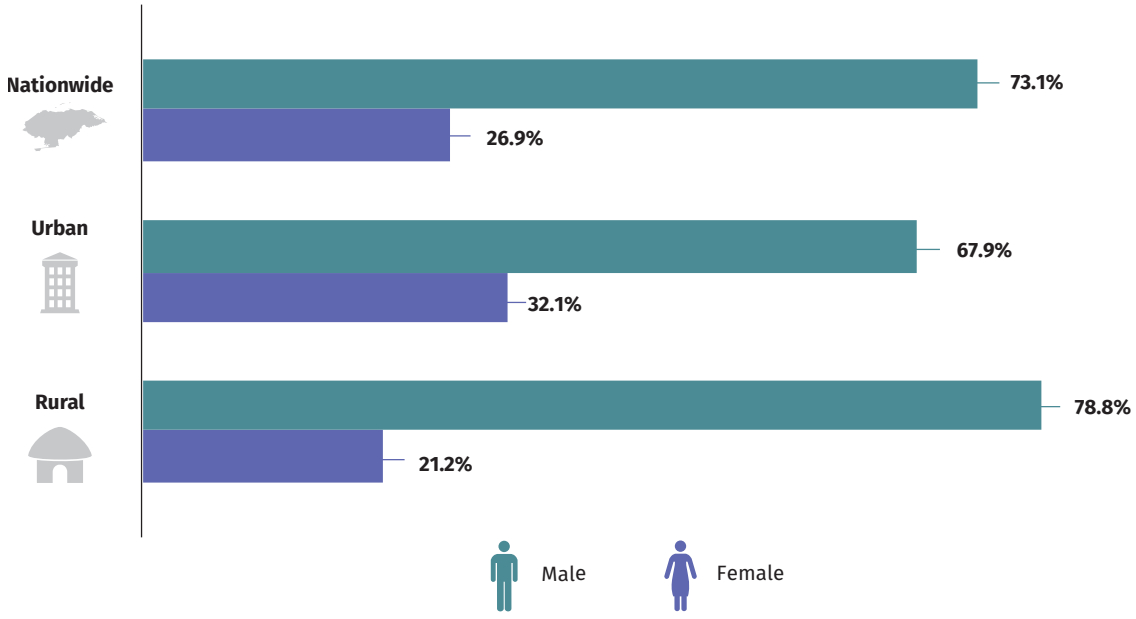
GENDER ANALYSIS

Photo: World Bank

HOW DO HOUSEHOLDS DIFFER BY GENDER OF HEAD OF HOUSEHOLD?

Nationwide, 73% of Honduran households are headed by men, and 27% of households are headed by women (Figure 60). Male-headed households account for 68% of urban households and 79% of rural households.

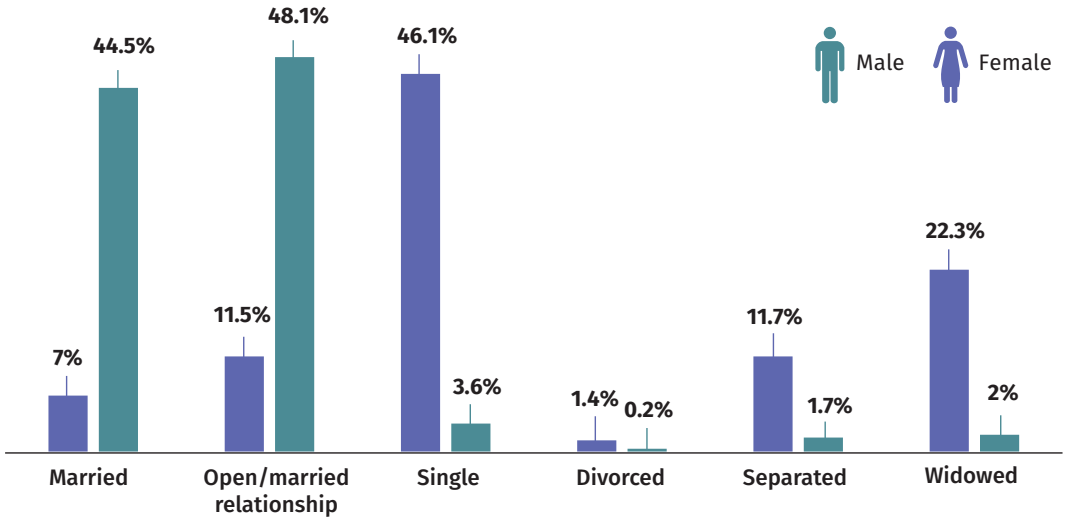
FIGURE 60 • **Distribution of households by gender of household head (nationwide, urban/rural)**



Note: Sample size = 2,813 households. Two observations dropped for which the gender of the head of household is missing.

Female household heads are older than male-headed households (54 years and 47 years, respectively), live in slightly smaller families (4 and 4.5 members, respectively), have a lower average income (US$3,576.71 and US$3,874.36 total average annual expenditure, respectively) and level of education. Single and widowed women make up the majority of female household heads (46.1% and 22.3%, respectively), while most male household heads are married or in an open relationship (44.5% and 48.1%, respectively) (Figure 61).

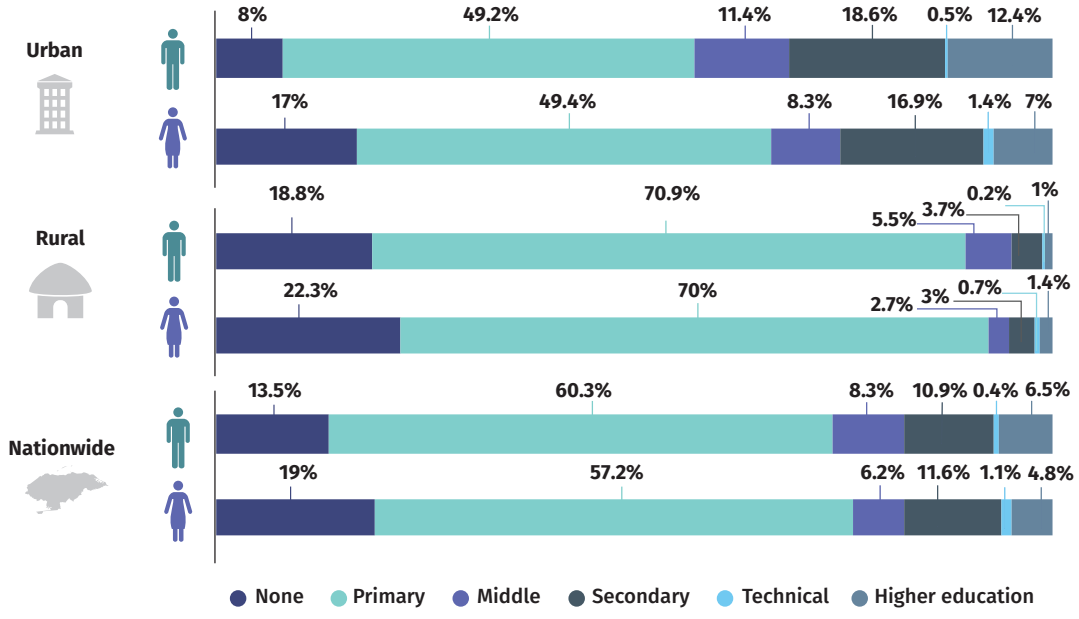
FIGURE 61 • **Marital status of household head, by gender of household head (nationwide)**



Note: Sample size = 2,813 households.

Male household heads are slightly more likely to complete a higher education than female household heads (Figure 62). Nationwide, 4.8% of female household heads received a higher education, compared with 6.5% of male household heads; further, 17% of female household heads have never attended school, while this is the case for 8% of male household heads. Educational disparities between female and male household heads remain in both urban and rural areas. In rural households, 22.3% of female heads and 18.8% of male heads have not attended school. In urban areas, 19% of female heads have not received formal education, compared to 13.5% of male heads.

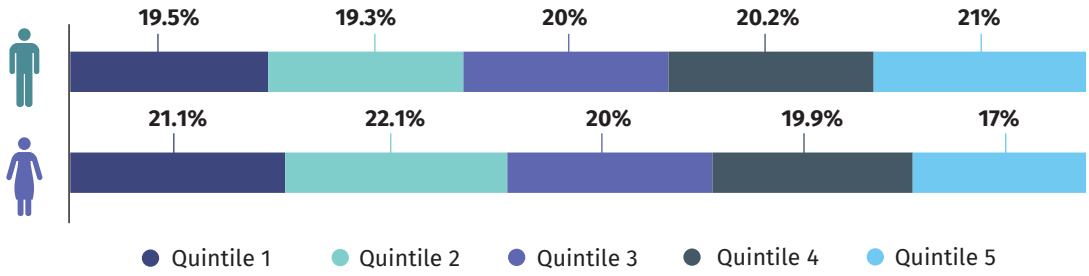
FIGURE 62 • **Education level by gender of household head (nationwide, urban/rural)**



Note: Sample size = 2,813 households.

Nationwide, female-headed households spend about HNL 585 (US$25) less per month than male-headed households. The average monthly expenditure for female-headed households and male-headed households is HNL 7,034.2 (US$298) and HNL 7,619.6 (US$323), respectively. Overall, 43.2% of female-headed households are in the bottom two quintiles compared with 38.8% of male-headed households, without any significant difference between rural and urban areas (Figure 63). The gender disparity in the higher quantiles is not as much: in the highest quintile, the share of female-headed households stands at 17%, as opposed to 21% for male-headed households. Consequently, from the MTF survey dataset in Honduras, it is not possible to identify a significant difference in household income and expenditure between the two groups, by gender.

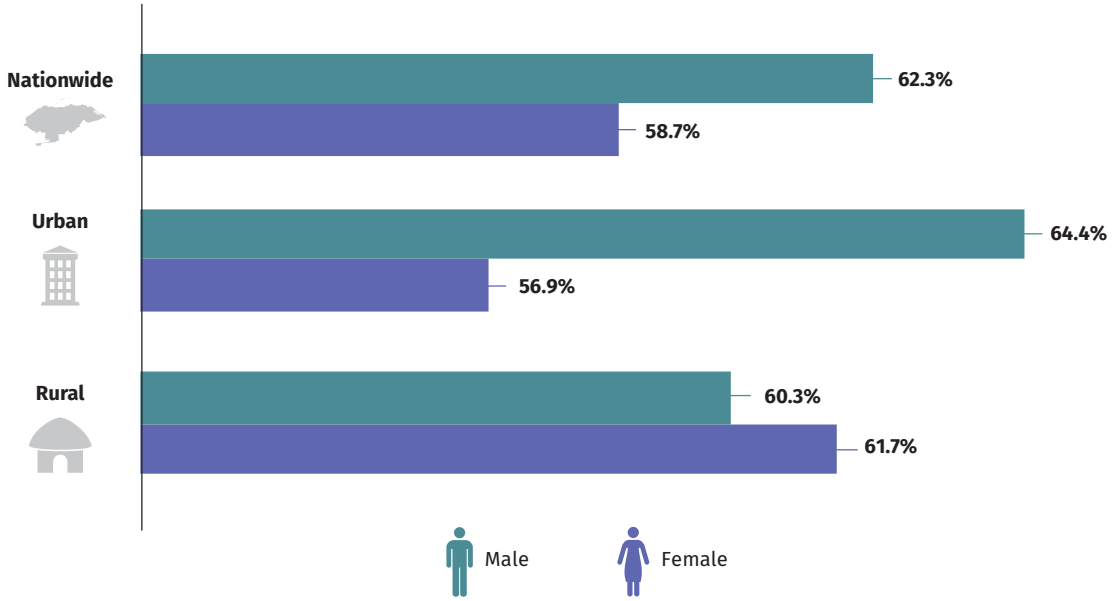
FIGURE 63 • **Distribution of households by expenditure quintile, by gender of household head (nationwide)**



Note: Sample size = 2,813 households.

Only 58.7% of female-headed household reported access to loans or credit, compared with 62.3% of male-headed households (Figure 64). When access is compared within urban areas, the gender gap increases. Only 56.9% of female-headed households had access to loans or credit compared with 64.4% of male-headed households. In rural areas, 61.7% of female-headed households have access to loans or credit, compared with 60.3% of male-headed households.

FIGURE 64 • **Access to finance (loan/credit) by gender of household head (nationwide, urban/rural)**



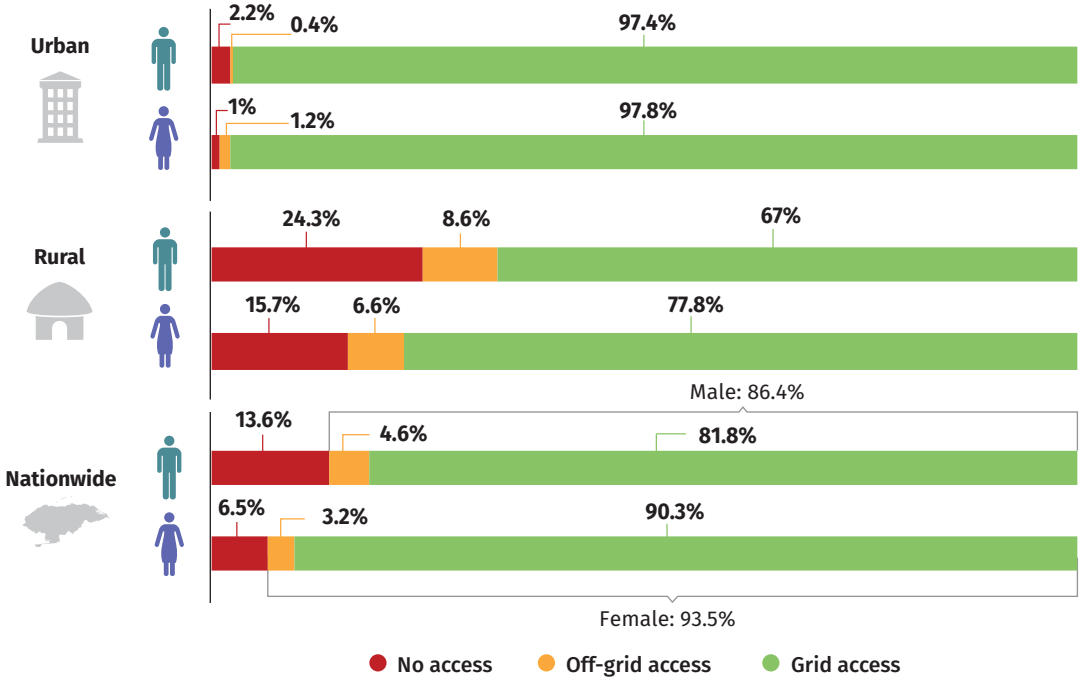
Note: Sample size = 1,737 households.

ACCESS TO ELECTRICITY

Nationwide, 6.5% of female-headed households and 13.6% of male-headed households have no access to electricity (Figure 65). At the national level, the percentage of female-headed households connected to the national grid is slightly higher than that of male-headed households, while there is no difference in urban areas. However, this is partly because female-headed households are slightly more likely to be in urban areas, which have high electrification rates.

Among households with no access to electricity, female-headed households are poorer than male-headed households: 62.1% of female-headed households without electricity are in the lowest expenditure quintile, compared with 55.9% of male-headed households. The difference in access to electricity between rural and urban areas is substantial. In rural areas, more male-headed households have no electricity source (24.3%), compared with female-headed households (15.7%).[26] Male-headed households are more likely to use off-grid solutions compared to female-headed households. In urban areas, the gender gap does not remain.

FIGURE 65 • **Access to electricity by technology, by gender of household head (nationwide, urban/rural)**



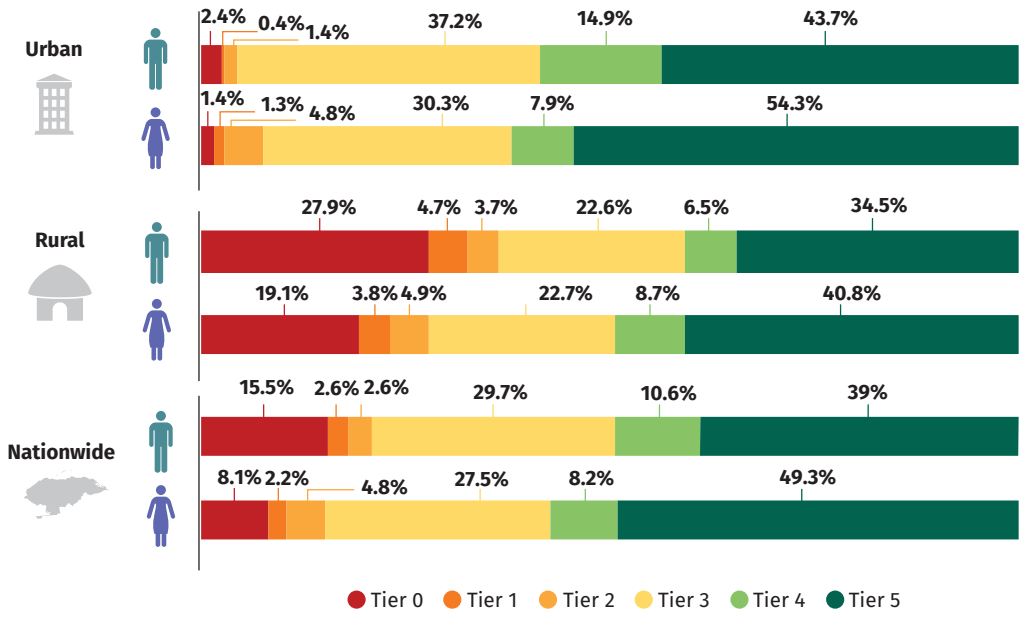
Note: Sample size = 2,810 households.

Female-headed and male-headed households have similar distributions in middle tiers of the MTF aggregate tier for access to electricity, but some variations exist in the lowest and highest tiers. Nationwide, 8.1% of female-headed households and 15.5% of male-headed households are in Tier 0, while 49.3% of female-headed households and 39% of male-headed households are in Tier 5. Regardless of urban or rural area, male-headed households are in lower tiers compared to female-head households. For instance, Figure 66 shows that in rural areas, 19.1% of female-headed households are in Tier 0, compared with 27.9% of male-headed households. The higher concentration of male-headed

[26] The off-grid breakdown reveals that there is no significant difference between male- and female-headed households.

households in lower tiers is due to Capacity issues (because they are less likely than female-headed households to have a grid connection and are more likely to have off-grid solutions). In urban areas, 54.3% of female-headed households are in Tier 5, compared with 43.7% of male-headed households.

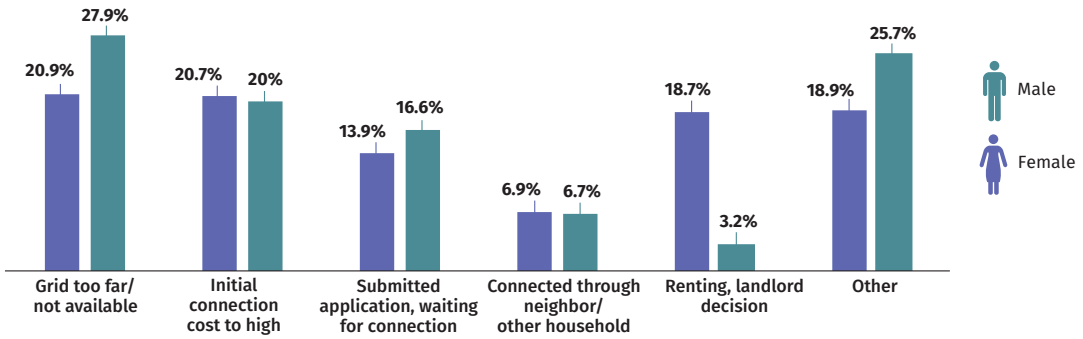
FIGURE 66 • **MTF electricity tier distribution, by gender of household head (nationwide, urban/rural)**



Note: Sample size = 2,813 households.

Figure 67 shows that male- and female-headed households identify "grid too far or unavailable" as the main reasons they were not connected to the grid. Another barrier preventing these households from gaining a connection is the high connection cost (about 20% each for both categories). Among households that identify high connection cost as the main barrier, more male-headed households (38.3%) are in the lowest expenditure quintile compared to female-headed households (10.4%). Compared to female-headed households (almost 14%), a larger portion of male-headed households (16.6%) reported that they had submitted an application for a connection but had not been connected yet. Finally, one key area in which male- and female-headed households differ is when the landlord can choose whether to connect the dwelling to a grid. In that case, 18.7% of female-headed households and 3.1% of male-headed households have claimed that they are currently renting and the final decision to connect their housing unit to a grid belongs to the landlord.

FIGURE 67 • **Barriers to gaining access to the electricity grid (nationwide)**



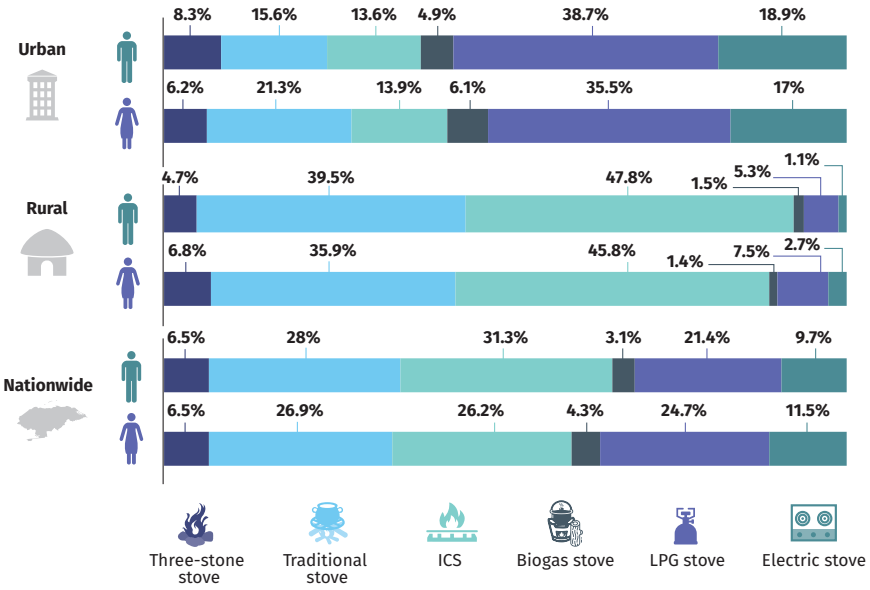
Note: Sample size = 796 households.

ACCESS TO MODERN ENERGY COOKING SOLUTIONS

Nationwide, female-headed households are somewhat more likely to use clean fuel stoves than male-headed households, but there is no gender gap in the use of three-stone or traditional stoves. ICSs are used more by male-headed households (31.3%) than by female-headed households (26.2%).

Ownership of traditional stoves is lower among female-headed rural households (almost 36%), but higher in female-headed urban households (21.3%), than among male-headed households (39.5% rural and 15.6% urban, respectively). An opposite trend exists in relation to three-stone stove ownership (Figure 68). There is not much difference between male- and female-headed households for clean fuel stoves, despite the relatively high expense for LPG and electricity.

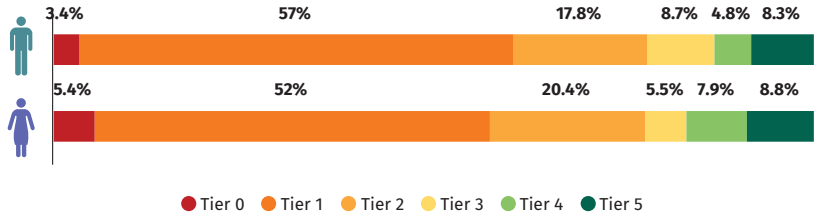
FIGURE 68 • **Access to cooking solutions, by type of primary cookstove, by gender of household head (nationwide, urban/rural)**



Note: Sample size = 2,749 households.

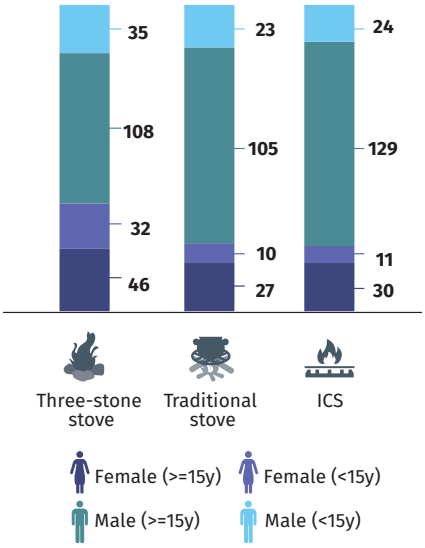
Figure 69 indicates that male- and female-headed households also have similar access to modern energy cooking solutions. Nationwide, 72.4% of female-headed households and 74.8% of male-headed households are in lower tiers (Tiers 1 and 2), while 8.8% and 8.3% of female- and male-headed households, respectively, are in the highest tier for access to modern energy cooking solutions. There is a small gender gap in the use and access to a modern energy cooking solution, although the amplitude is low.

FIGURE 69 • **MTF tier distribution, by gender of household head (nationwide, urban/rural)**



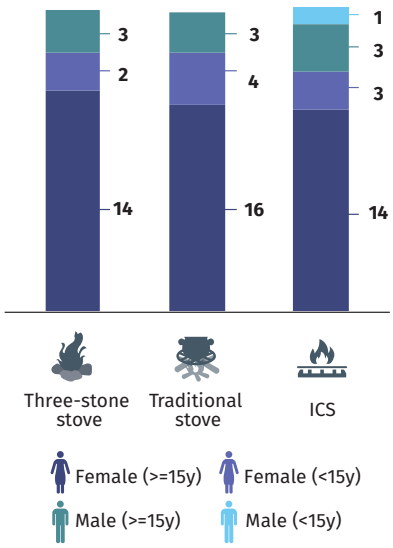
Women aged 15 and older spend a considerably higher amount of time in both fuel preparation and cooking compared to the other three groups (girls, boys, and men). The time spent cooking by other members is negligible compared to that by women (Figures 70–72). Therefore, compared to men and boys, women are much more likely to be affected by indoor air pollution and are more likely to benefit from cleaner cooking solutions. Male household members are more responsible for fuel collection (this gender distinction is not typically found in other countries). By switching to a clean fuel stove, both men and women would expect to reduce time spent acquiring (through collection or purchase) and preparing fuel.

FIGURE 70 • **Average fuel collection time (minutes/day), by primary stove type, by gender (nationwide)**



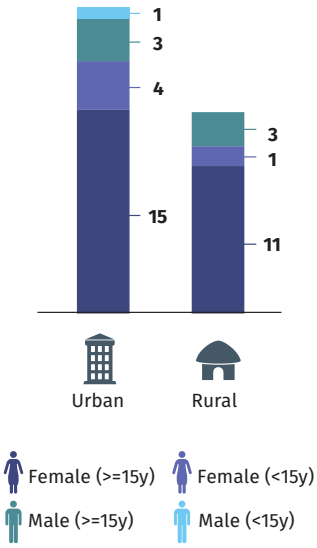
Note: Sample size = 2,815 households.

FIGURE 71 • **Average fuel preparation time (minutes/day), by primary stove type, by gender (nationwide)**



Note: Sample size = 2,815 households.

FIGURE 72 • **Average cooking time (minutes/day), by gender (urban/rural)**



Note: Sample size = 2,815 households.

POLICY RECOMMENDATIONS

The MTF analysis does not show significant gender gap between female- and male-headed households. Female-headed households appear to be slightly more vulnerable than male-headed households: about 24% of them are widows or divorced, tend to be poorer (especially in rural areas), and are less educated. However, the MTF analysis shows that the percentage of female-headed households who are connected to the national grid and use clean fuel stoves is slightly higher than that of male-headed households.

The percentage of female-headed households connected to the national grid is slightly higher than that of male-headed households, but there is no difference in urban areas. However, this is partly because female-headed households are slightly more likely to live in urban areas, which have high electrification rates. Female- and male-headed households have similar distributions in middle tiers of the MTF aggregate tier for access to electricity, but some variations exist in the lowest and highest tiers. The situation differs between rural and urban areas, but regardless of area, male-headed households are in lower tiers compared to female-head households. Further research should be carried out to identify their needs and priorities, and possible ways to overcome barriers to energy access.

Nationwide, in relation to cooking technologies, female-headed households are somewhat more likely to use clean fuel stoves than male-headed households, while there is no gender gap in the use of three-stone or traditional stoves. Women aged 15 and older spend a considerably higher amount of time in both fuel preparation and cooking compared to men, girls, and boys. Women are thus much more likely to be affected by indoor air pollution, time poverty, and drudgery. Hence, cooking solutions may have a larger impact on women compared to the other three groups. Male household members are more responsible for fuel collection, being this a quite distinctive patterns compared to other countries. By switching to a clean fuel stove, both men and women would expect to reduce time spent acquiring (through collection or purchase) and preparing fuel. Education campaigns could raise awareness on the benefits of clean and efficient cooking solutions that target men and women.

ANNEX 1.
Multi-Tier Frameworks

TABLE A 1.1 • **Multi-Tier Framework for Measuring Access to Electricity**

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

Source: Bhatia and Angelou 2015.
Note: Color signifies tier categorization.

TABLE A 1.2 • **Multi-Tier Framework for Measuring Access to Modern Energy Cooking Solutions**

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

Source: Bhatia and Angelou 2015; ISO 2018

Note: Colors signify tier categorization

Note: ISO = International Organization for Standardization; PM = ; mg/MJd = ; CO = ; g = .

Note: Cookstove Efficiency not used as an attribute to calculate the final tier in Honduras. Volume of kitchen not used to calculate the tier for subattribute Ventilation for the attribute Cooking Exposure due to data limitations, which hindered making this calculation.

ANNEX 2.
Sampling Strategy

SAMPLE SIZE CALCULATION PARAMETERS

The sample size proposed for the MTF countries is designed to get sufficiently precise estimates of each tier at national, urban, and rural levels. A much smaller sample size would have been adequate to produce precise estimates at the national level within those domains. This section discusses the factors to consider in determining sample size calculation, and provides a justification for the proposed sample size for each country. Major issues in determining the appropriate sample size for a survey are the following:

- Precision of survey estimates (sampling error)
- Quality of data collected by the survey (nonsampling error)
- Cost in time and money of data collection, processing, and dissemination

Precision of survey estimates. The concept of the precision of a sample survey estimate is crucial in determining the sample size. By definition, a sample from a population is not a complete picture of the population. However, an appropriately drawn random sample of reasonable size can provide a clear picture of the characteristics of that population, certainly sufficient for policy implication or decision-making purposes. From a sample of households, one can collect data and generate a sample (or survey) estimate of a population parameter. The population parameter value of a characteristics of interest is generally unknown. Sampling errors (or margin of errors) depend very much on the size of the sample, and very little on the size of the population. To maximize the sample size and to reduce the sampling error, the prevalence rate in this calculation is 50%. The formula (B.1) to calculate the sample size is as follows:

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

where:

n = Sample size to be determined.

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

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

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

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

m = Average number of households selected per PSU.

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

e = Margin of error, or level of precision. We apply various levels of margin of error from 1% to 5.5% to the calculation.

Quality of data (nonsampling error). Beside sampling errors, data from a household survey are vulnerable to other inaccuracies from causes as diverse as refusals, respondent fatigue, measurement errors, interviewer errors, or the lack of an adequate sample frame. These are collectively known as nonsampling errors. Nonsampling errors are harder to predict and quantify than sampling errors, but it is well accepted that good planning, management, and supervision of field operations are the most effective ways to keep them under control. Moreover, it is likely that management and supervision will be more difficult for larger samples than for smaller ones (Grosh and Muñoz 1996, 56). Thus, one would expect nonsampling errors to increase with sample size, and we would like to limit the sample size to less than 5,000.

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

SAMPLE SIZE CALCULATION

The sample size for the country was calculated using the prevalence rate of 50% as the most conservative choice and to achieve the minimum margin of error. A nonresponse rate of 10% and a value of 1.1 for nonresponse rate were considered. The number of households selected per PSU was 12. Due to the characteristics of infrastructure variables and indicator, 0.45 for intracluster relation coefficient was selected, which determined a design effect equal to 6.

In the process of defining a strategy to calculate the sample size for the selected countries, the sample size was calculated using the distribution between urban and rural as two analytic domains. Then these two values were added to obtain the national sample size. Following this approach, a margin of error of 6.2% at urban and rural levels gives a national sample size of 3,324 households with an error of 4.4%, of which 1,656 households are urban and 1,668 households are rural.

Thus, the household survey sample selection is based on a three-stage stratification strategy, aimed at being representative of both urban and rural populations.[27] The survey was implemented in 16 out of 18 departments, following the same approach adopted by the National Institute of Statistics (INE) to produce the Master Sample. The MTF Sample Framework is based on the Master Sample based on the last Population and Housing Census, prepared by the INE in 2013 (INE 2015).

The departments of Gracias a Dios and Islas de la Bahía are excluded from the survey, and they are not even included in the master sample and official surveys of INE. The reasons include the following. First is the low population weight—both departments represent less than 1% of the total national census segments of INE. Second, there is a high relative cost of access and internal mobilization. The two departments are accessible only by plane: Islas de la Bahía is a tourist destination, and in Gracias a Dios, the cayucos and small boats are the only means of transport. Third, part of the population in Gracias a Dios communicate in a local dialect (Miskito), and in Islas de la Bahía, only a minor part of the population speak English.

Finally, the electrification conditions in both departments are peculiar. In Islas de la Bahía, energy has a thermal source, produced by a private company that is in the process of becoming managed by the municipality. Since fuel and other inputs are carried from the mainland, production costs and, therefore, energy prices are particularly high. Gracias a Dios has only a few electrified communities, and, given the limited communication channels and the dispersion of households throughout the jungle area, the costs of bringing energy in this area are high. For these reasons, both departments are usually excluded from the household surveys in the country, including official surveys implemented by INE.

INE provided advice on the sampling strategy and supported the MTF team in identifying the electrification status of the EAs, identified as enumeration areas, sectors, or PSUs.[28] The team surveyed 3,324 households in 276 EAs, equally split between urban and rural areas, in 16 departments, following the stratification criteria: 50–50 ratio of electrified and nonelectrified households for the tier analysis and equal allocation between urban and rural areas.

Even though the original sample size was as planned (3,324 households, of which 1,668 are in rural and 1,656, urban), the final sample size was reduced considerably due to the high nonresponse rate. The actual sample size is 2,815 households, of which 1,574 are rural and 1,241, urban. The reduction of the sample size was due to (i) the exclusion of two departments from the survey in line with INE's strategy and (ii) the high nonresponse rate in urban areas because of safety issues, which may partially affect the reliability of the results and the standard errors. The outcomes of the MTF analysis, thus, have to be read considering these limitations. The sample of electrified and nonelectrified sectors was drawn in a particular way by the firm, given that most of the population in Honduras is connected to the grid and only a few segments are not electrified.

In rural areas, to maintain the department structure of the Master Sample, the sample of sectors was distributed proportionally to the number of sectors by department (excluding Gracias a Dios and Islas de la Bahía). To have a larger number of sectors with no access to the national grid, the firm oversampled the substratum of sectors, with some segments with no access the national grid, as shown in Table B.1.

[27] The political division of Honduras is made up of 18 departments,298 municipalities, 3,714 villages, and 29,950 caseríos (409 urban and 29,541 rural).
[28] Within each sector the firm selected a segment.

TABLE B 2.1 •**Rural area, distribution of the MTF sample of sectors for access to the national grid, by department**

Department	Sectors with some segments with no access to national grid[a]	Sectors with all segments with access to national grid[a]	Total
1 Atlántida	2	3	5
2 Colón	3	3	6
3 Comayagua	4	5	9
4 Copán	4	5	9
5 Cortes	5	7	12
6 Choluteca	4	5	9
7 El Paraíso	5	6	11
8 Francisco Morazán	7	7	14
10 Intibucá	3	4	7
12 La Paz	2	3	5
13 Lempira	5	5	10
14 Ocotepeque	2	2	4
15 Olancho	6	6	12
16 Santa Bárbara	5	6	11
17 Valle	2	2	4
18 Yoro	5	5	10
Total	**64**	**74**	**138**

a. Segments that have 3% or more of households connected to the national grid are classified as having "access to the grid"; otherwise, they are classified as "no access to the grid."

To maintain the structure of the Master Sample for urban areas, the sample of sectors was distributed proportionally to the number of sectors by strata resulting from matching geographical domains and departments. The firm oversampled subsection of sectors with a segment that had a percentage lower than 97% of the households connected to the national grid, according to the Population and Housing Census of 2013 (INE 2015) (Table B.2.)

TABLE B 2.2 • **Urban area, distribution of the MTF sample of sectors by domain and access to the national grid, by department**

Department	Central district (substratum)		San Pedro Sula (substratum)		Median cities (substratum)		Small cities (substratum)		Total
	1a	2b	1 a	2b	1a	2b	1a	2b	
Atlántida	0	0	0	0	5	1	1	1	8
Colon	0	0	0	0	1	0	2	1	4
Comayagua	0	0	0	0	3	1	1	1	6
Copan	0	0	0	0	1	0	1	1	3
Cortes	0	0	27	3	9	1	8	1	49
Choluteca	0	0	0	0	1	1	1	1	4
El Paraíso	0	0	0	0	1	0	1	1	3
Francisco Morazán	30	4	0	0	0	0	3	1	38
Intibucá	0	0	0	0	0	0	1	1	2
La Paz	0	0	0	0	0	0	1	1	2
Lempira	0	0	0	0	0	0	1	0	1
Ocotepeque	0	0	0	0	0	0	1	0	1
Olancho	0	0	0	0	2	1	1	0	4
Santa Bárbara	0	0	0	0	0	0	3	1	4
Valle	0	0	0	0	1	0	1	0	2
Yoro	0	0	0	0	3	1	2	1	7
Total	**30**	**4**	**27**	**3**	**27**	**6**	**29**	**12**	**138**

a.Sectors with *some* segments with <97% of the households *connected* to the national grid.

b. Sectors with *all* the segments with >=97% of the households *connected* to the national grid.

SELECTION OF SECTORS (PSUS) AND SEGMENTS

Within each selection stratum, the number of sectors was selected systematically, with random start, subject to geographic ordering, to have an implicit substratification in line with the indicated strategy (Tables B.1 and B.2). Within each sector, a census segment was selected with simple random sampling, so that in the MTF sample, the number of census segments is equal to the number of sectors. Given that the segment was randomly selected within each sector, the distribution of the sample of segments by the substrata of access to the grid is random.

The segments in the MTF sample are classified according to the degree of grid access in 2013, when the Population and Housing Census was carried out (INE 2015). The distribution is presented in Table B.3 for rural areas and in Table B.4 for urban areas.

TABLE B 2.3 • **Rural area, distribution of segments in selected sample by degree of access to the national grid in 2013, by department**

Department	Access rate of segment to the national grid				Total segments in rural stratum
	Segments with <3% connected households	Segments with 3% to <50% connected households	Segments with 50% to <97% connected households	Segments with >=97% connected households	
Atlántida	0	2	2	1	5
Colon	3	1	2	0	6
Comayagua	2	3	3	1	9
Copan	1	2	4	2	9
Cortes	1	1	7	3	12
Choluteca	2	3	4	0	9
El Paraíso	2	2	6	1	11
Francisco Morazán	3	4	7	0	14
Intibucá	2	1	3	1	7
La Paz	1	3	1	0	5
Lempira	3	1	5	1	10
Ocotepeque	2	0	2	0	4
Olancho	2	3	7	0	12
Santa Bárbara	2	4	4	1	11
Valle	2	1	1	0	4
Yoro	4	1	3	2	10
Total	**32**	**32**	**61**	**13**	138

TABLE B 2.4 • **Urban area, distribution of segments in selected sample by degree of access to the national grid in 2013, by department**

Department	Access rate of segment to the national grid				Total segments in urban stratum
	Segments with <3% connected households	Segments with 3% to <50% connected households	Segments with 50% to <97% connected householdsa	Segments with >=97% connected households	
Atlántida	0	0	1	7	8
Colon	0	0	3	1	4
Comayagua	0	0	2	4	6
Copan	0	0	1	2	3
Cortes	1	1	15	32	49
Choluteca	0	0	1	3	4
El Paraíso	0	0	1	2	3
Francisco Morazán	0	1	17	20	38
Intibucá	0	0	0	2	2
La Paz	0	0	1	1	2
Lempira	0	0	0	1	1
Ocotepeque	0	0	0	1	1
Olancho	0	0	1	3	4
Santa Bárbara	0	0	2	2	4
Valle	0	0	2	0	2
Yoro	0	0	3	4	7
Total	**1**	**2**	**50**	**85**	**138**

a. Only 6 segments had <80% of the households connected to the national grid in 2013.

SELECTION OF HOUSEHOLDS

Procedure in rural areas

To capture a larger number of households not connected under the restrictions of the sample size calculated for the rural area (1,656 households) and the degree of accessibility that the segments of the MTF sample had to the grid in 2013, the firm oversampled the segments with the lowest percentage of households connected to the grid, in the following ways. (Table B.5 shows a summary of the number of dwellings interviewed in rural areas.)

Segments with less than 50% of the households connected to the network. In each segment of the sample, four starting points were selected, each one defining a subcluster of four households each, for a total of 16 households per segment. Bearing in mind the total number of households in the sample frame, four numbers (R1, R2, R3, R4) were randomly selected with random start in a systematic way.

These random numbers identified four subclusters of four households each. The first random number, R1, determined the starting point of the first subcluster. The starting point was the household in which R1 households accumulated. Following the numbering in the cartography, a total of four eligible

households (i.e., occupied private dwelling) for the subcluster were selected. The same was done for the other three random numbers to identify the 16 eligible households in the segment, not necessarily physically adjacent to each other.

For segments with 50% to less than 97% of the households connected to the network. The firm selected two starting points, defining two subclusters of four households each, for a total of eight households per segment.

For segments that have 97% or more of the households connected to the network. Three starting points were selected, defining three subclusters of four households each, for a total of 12 households per segment.

TABLE B 2.5 • **Rural area, distribution of households in sample by degree of access to the national grid in 2013, by department**

Department	Access rate of segment to the national grid				Total segments in rural stratum
	Segments with <3% connected households	Segments with 3% to <50% connected households	Segments with 50% to <97% connected households	Segments with >=97% connected households	
Atlántida	0	32	16	12	60
Colon	48	16	16	0	80
Comayagua	32	48	24	12	116
Copan	16	32	32	24	104
Cortes	16	16	56	36	124
Choluteca	32	48	32	0	112
El Paraíso	32	32	48	12	124
Francisco Morazán	48	64	56	0	168
Intibucá	32	16	24	12	84
La Paz	16	48	8	0	72
Lempira	48	16	40	12	116
Ocotepeque	32	0	16	0	48
Olancho	32	48	56	0	136
Santa Bárbara	32	64	32	12	140
Valle	32	16	8	0	56
Yoro	64	16	24	24	128
Total	**512**	**512**	**488**	**156**	**1,668**

Procedure in urban areas

The households in all the segments of the sample in urban area were selected following the same procedure, which consists of selecting three random starting points to define three subclusters of four households each, for a total of 12 households by segment. Table B.6 shows a summary of the number of households interviewed in urban area.

TABLE B 2.6 • **Urban area, distribution of households in sample by degree of access to the national grid in 2013, by department**

Department	Access rate of segment to the national grid				Total segments in urban stratum
	Segments with <3% connected households	Segments with 3% to <50% connected households	Segments with 50% to <97% connected households	Segments with >=97% connected households	
Atlántida	0	0	12	84	96
Colon	0	0	36	12	48
Comayagua	0	0	24	48	72
Copan	0	0	12	24	36
Cortes	12	12	180	384	588
Choluteca	0	0	12	36	48
El Paraíso	0	0	12	24	36
Francisco Morazán	0	12	204	240	456
Intibucá	0	0	0	24	24
La Paz	0	0	12	12	24
Lempira	0	0	0	12	12
Ocotepeque	0	0	0	12	12
Olancho	0	0	12	36	48
Santa Bárbara	0	0	24	24	48
Valle	0	0	24	0	24
Yoro	0	0	36	48	84
Total	**12**	**24**	**600**	**1020**	**1,656**

SAMPLE WEIGHTING CALCULATIONS

To have valid estimates of the parameters of the target population and adequately estimated sample errors, the sample design should be considered in its calculation. It is necessary to apply weights to the sample's results to correct or reduce biases that may be introduced by selection with unequal probabilities or nonsampling errors (for example, refusals). The sample design weight is calculated as the inverse of the selection probability (B.2):

$$w_i = \frac{1}{p} \qquad \text{(B.2)}$$

Where:

p is the probability of a unit to be included in the sample.

The sample of households of the MTF survey was selected from the Master Sample of sectors (PSU) in three stages: in the first stage a subsample of sectors was selected from the Master Sample; in a second stage a segment was selected in each sector of the MTF sample; in the third stage the households were selected within the segments of the MTF sample. The final probability of selecting the households was calculated by multiplying the probability of selecting the sectors of the Master Sample by the conditional probabilities of each stage and the basic expansion factor as the inverse

of the probability of selection. The following paragraphs explain the sample weighting calculation in more detail.

Selection probabilities of sectors (PSUs) in Master Sample

INE provided the firm with the selection probabilities of the sectors (PSUs) in the Master Sample. These sectors were selected in a single stage, except for the small cities in the urban area, which were selected in a previous stage within each department. The probability of selecting sector i of stratum h in the Master Sample (except for small cities) is as shown (B.3):

$$p_{hi} = \frac{n_h * M_{hi}}{M_h} \qquad \text{(B.3)}$$

Where:

n_h: number of sectors selected in stratum h.

M_h: total number of households within stratum h.

M_{hi}: total number of households in sector i within stratum h.

In the case of small cities, the selection probability was calculated as follows (B.4):

$$p_{hgi} = \frac{c_h * M_{hg}}{M_h} \frac{n_{hg} * M_{hgi}}{M_{hg}} \qquad \text{(B.4)}$$

Where:

c_h: number of small cities in the sample within stratum h.

M_{hg}: number of households in the small city g within stratum h.

M_h: number of households of all small cities within stratum h.

n_{hg}: number of sectors in the sample within the gth small city of stratum h.

M_{hgi}: number of households in sector i, small city g of stratum h.

Selection probabilities and expansion factors in the MTF sample

According to the sample design implemented, the probability of selecting a household in segment j of sector i in the stratum h' of the MTF sample is given as shown (B.5):

$$p_{h'ij} = p_{hi} \frac{n_{h'}}{N_{h'}} \frac{1}{L_{h'i}} \frac{m_{h'ij}}{M_{h'ij}} \qquad \text{(B.5)}$$

phi: probability of selecting sector i of stratum h in the Master Sample in case that small cities is phgi instead of phi.

n_h: number of sectors selected in stratum h' in the sample.

$N_{h'}$: number of sectors in stratum h' of the sample frame of the MTF sample.

$L_{h'i}$: number of segments in sector i of stratum h' of the sample frame of the MTF sample.

$M_{h'ij}$: current number of households in the sample segment j of sector i of stratum h'.

$m_{h'ij}$: number of households selected within the jth sampling segment of sector i of stratum h'; it is equal to 12 in segments in urban area; 16 in segments in rural areas with less than 50% of their households connected to the energy grid in 2013; 8 in segments in rural areas between 50% and 97% of connected households; 12 segments in rural areas with 97% or more connected households.

The basic expansion factor for all households selected in the jth segment of the ith sampling sector of stratum h' is equal to the inverse of their probability of selection as shown (B.6):

$$W_{h'ij} = \frac{1}{p_{h'ij}} \qquad \text{(B.6)}$$

An expansion factor was calculated for each sample segment. This basic expansion factor was adjusted by the eventual nonperformance of some segments and by the nonresponse at the household level.

If $n_{h'}$ is the number of segments selected and $n'_{h'}$ is the number of segments made in the stratum h' of the MTF sample, the response rate at the segment level in that stratum is given as shown (B.7):

$$T_{sh'} = \frac{n'_{h'}}{n_{h'}} \qquad \text{(B.7)}$$

The response rate at the household level in stratum h' to adjust the expansion factors is calculated as follows (B.8):

$$T_{hh'} = \frac{\sum W_{h'ij} m'_{h'ij}}{\sum W_{h'ij} m_{h'ij}} \qquad \text{(B.8)}$$

Where the sum is over all segments in stratum h'.

$Wh'ij$: basic expansion factor for all households selected in the j^{th} segment of the i^{th} sampling sector of stratum h'.

$m_{h'ij}$: number of households selected within the j^{th} sampling segment of sector i of stratum h'.

$m'_{h'ij}$: number of households interviewed within the j^{th} sampling segment of sector i of stratum h'.

Finally, the expansion factor adjusted for all households in the j^{th} sampling segment of the i^{th} sample sector of stratum h' is shown as follows (B.9):

$$W'_{h'ij} = \frac{W_{h'ij}}{T_{sh'} T_{hh'}} \qquad \text{(B.9)}$$

ANNEX 3.
Cookstove Typology

Three-stone stove. Characterized by a pot balanced on three stones over an open fire. Fuel use and emissions are high, and thermal efficiency and safety are low. Three-stone stoves usually use firewood, but other solid fuels may be used. Fuel rests on the ground.

Traditional stove (traditional *fogón* without chimney). Locally produced using mud, metal, or other low-cost materials and following cultural practices. Fire is enclosed in the combustion chamber, which is not fully insulated. The pot is often raised above the fire, allowing more time for combustion. It uses firewood. Fuel rests on the ground.

Improved cookstove (ICS) with chimney. Combustion chamber is well insulated, and the chimney takes most of the emission outside the kitchen, producing less indoor and overall air pollution. It uses newer stove technology to improve efficiency, cleanliness, and safety. It uses firewood. Fuel rests on a shelf.

Rocket stove (RS) gasifier (*ecofogón*). An efficient, hot burning stove that uses small-diameter wood fuel. Fuel is burned in a simple combustion chamber containing an insulated vertical chimney, which ensures almost complete combustion prior to the flames reaching the cooking surface.

Biogas stove. Uses biogas made of primarily methane and carbon dioxide. It provides instant heat upon ignition, so no preheating of fuel or waiting time is needed.

Liquid petroleum gas (LPG) stove. Typically contains a steel cylinder filled with LPG, a pressure controller, a tube connecting the cylinder to the pressure controller and the burner, and the burner itself. It is convenient because it heats up quickly and the temperature can be precisely controlled. It uses fuel obtained during petroleum refining (mainly butane or propane). LPG fuel can also be obtained from fossil coal. LPG fuel is generally nontoxic, easy to handle, energy efficient, and burns very cleanly. It requires higher capital investment into devices and higher running costs for fuel than for many other stoves.

Electric stove. Works with electricity and is considered the cleanest of all stove types.

REFERENCES

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

Blackden, M., and Q. Wodon, ed. 2006. "Gender, Time Use, and Poverty in Sub-Saharan Africa." World Bank Working Paper 73, World Bank, Washington, DC.

Clancy, J. S., M. Skutch, and S. Batchelor. 2003. *The Gender–Energy–Poverty Nexus: Finding the Energy to Address Gender Concerns in Development*. DFID Project CNTR998521. London, U.K.: Department for International Development.

Dherani, M., D. Pope, M. Mascarenhas, K. R. Smith, M. Weber, and N. Bruce. 2008. "Indoor Air Pollution from Unprocessed Solid Fuel Use and Pneumonia Risk in Children Aged Under Five Years: A Systematic Review and Meta-Analysis." *Bulletin of the World Health Organization* 86 (5): 390–98.

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

EnDev (Energising Development). 2017. *EnDev's Proxy-Indicator Approach for Assessing the Quality of a Cooking Energy System*. Eschborn, Germany: Deutsche Gesellschaft für Internationale Zusammenarbeit.

ENEE (Empresa Nacional de Energía Eléctrica). 2016. *Plan Estratégico ENEE 2016-2020*, 9. Tegucigalpa, M.D.C.: Empresa Nacional de Energía Eléctrica.

———. 2017. *Boletín de datos estadísticos. Gerencia de Planificación, Cambio e Innovación Empresarial*. Tegucigalpa, M.D.C.: Empresa Nacional de Energía Eléctrica. http://www.enee.hn/planificacion/2018/cobertura/PUB-COB-ELECT-MARZO-18%20(09-04-18).pdf.

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

Grosh, Margaret E., and Juan Muñoz. 1996. "A Manual for Planning and Implementing the Living Standards Measurement Study Survey." Living Standards Measurement Study Working Paper 26, World Bank, Washington, DC.

Gwavuya, S. G., S. Abele, I. Barfuss, M. Zeller, and J. Muller. 2012. "Household Energy Economics in Rural Ethiopia: A Cost-Benefit Analysis of Biogas Energy." *Renewable Energy* 48: 202–09.

IEA (International Energy Agency), IRENA (International Renewable Energy Agency), UNSD (United Nations Statistics Division), World Bank, and WHO (World Health Organization). 2018. *Tracking SDG7: The Energy Progress Report 2018*. Washington, DC: World Bank.

INE (National Institute of Statistics). 2015. *Censo de Población y Vivienda 2013*. Tegucigalpa: National Institute of Statistics.

ISO (International Organization for Standardization). 2018. *Clean Cookstoves and Clean Cooking Solutions: Harmonized Laboratory Test Protocols, Part 3: Voluntary Performance Targets for Cookstoves Based on Laboratory Testing*. Technical Report ISO/TR 19867-3 (October). Geneva: International Organization for Standardization. https://www.iso.org/standard/73935.html.

Pachauri S., Rao N.D., Cameron C. (2018) Outlook for modern cooking energy access in Central America. PLoS ONE 13(6): e0197974. https://doi.org/10.1371/journal.pone.0197974

Parikh, J. 2011. "Hardships and Health Impacts on Women Due to Traditional Cooking Fuels: A Case Study of Himachal Pradesh, India." *Energy Policy* 39 (12): 7587–94.

Rehfuess, E. A., S. Mehta, and A. Prüss-Üstün. 2006. "Assessing Household Solid Fuel Use: Multiple Implications for the Millennium Development Goals." *Environmental Health Perspectives* 114 (3): 373–78.

Smith, K. R., S. Mehta, and M. Maeusezahl-Feuz. 2004. "Indoor Air Pollution from Household Use of Solid Fuels." *In Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors*, edited by M. Ezzati, A. D. Lopez, A. Rodgers, and C. J. L. Murray, 1435–93. Geneva: World Health Organization.

UNDP (United Nations Development Programme). 2018. *Human Development Report.* New York: United Nations Development Programme. http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/HND.pdf.

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

Wang, X., J. Franco, O. R. Masera, K. Troncoso, and M. X. Rivera. 2013. *What Have We Learned about Household Biomass Cooking in Central America?* ESMAP Report 76222. Washington, DC: ESMAP/World Bank.

WHO (World Health Organization). 2014. *WHO Guidelines for Indoor Air Quality: Household Fuel Combustion.* Geneva: World Health Organization. http://apps.who.int/iris/bitstream/10665/141496/1/9789241548885_eng.pdf?ua=1.

World Bank. 2018. "Indicators: Agriculture & Rural Development," World Development Indicators (database), World Bank, Washington, DC, https://data.worldbank.org/indicator/.

———. 2019. *The World Bank in Honduras: Overview.* http://www.worldbank.org/en/country/honduras

WORLD BANK GROUP

ESMAP

SREP

MTF
Multi-Tier
FRAMEWORK