



MADAGASCAR

Integrated Energy Access Planning

SURVEY REPORT

JUNE 2024

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BACKGROUND

The Madagascar Integrated Energy Plan (IEP) is intended to synthesize an updated least-cost geospatial electrification plan with a clean cooking promotion plan and an energy supply investment plan in support of COVID-19 vaccine rollouts and improved agricultural cold chains. Development of the IEP will involve building a geospatial platform, which Malagasy stakeholders will be trained to use and renew as needed to support private-sector and government investments. Building the geospatial platform requires gathering data and information related to electrification expansion requirements; clean cooking interventions and market development; vaccine distribution and cold chain requirements; as well as cold chain expansion to support improved agricultural value chain development in Madagascar.

A consortium led by NRECA International (NRECA) is implementing the IEP project under contract with the Sustainable Energy for All (SEforALL) secretariat. SEforALL has asked NRECA International to prepare a proposal for an additional work package to perform additional primary data collection to fill the significant gaps in the available data across the three different project components. These key gaps relate to the quality and availability of electrical infrastructure data from JIRAMA, the national electric utility, as well as household and institutional cooking behaviours and energy expenditures. The proposal below is intended to mitigate these key data gaps while also maintaining the project timeline.

SCOPE OF PRIMARY DATA COLLECTION

The additional work package for the Madagascar IEP authorized primary data collection activity focused on a cooking and energy expenditure survey. NRECA deployed a team of survey specialists and enumerators to collect data on household and institutions' cooking behaviours and energy expenditures. The survey targeted three sample frames, with the sampling methodology summarized below.

The purpose of the energy expenditure and socio-economic survey was to evaluate existing energy demand through expenditure on fuels and energy services as well as to collect baseline demographic data related to gender, economic activities and income-growth potential from sampled households, small businesses, public facilities (health centres, schools) and other enterprises.

SURVEY DESIGN AND METHODOLOGY

Survey Instrument

Two survey instruments were developed and localized for the Madagascar IEP survey. First, an instrument for the household, small commercial and public facilities (schools and health clinics) energy expenditure survey was developed to collect demographic data, and data related to energy expenditure, consumption, appliance type and usage, household income and expenditure, and business type and income. A single survey form was used for all respondent types, with nested questions to guide enumerators based upon responses from the survey

respondents. The survey was designed to capture data for multiple analytical purposes. The survey modules included:

- Participant information including location, number of family members, sex of head of household, housing structure characteristics and other data.
- Demographic data including family size, income data, general expenditure data, etc.
- Energy expenditure and use by energy source.
- Household business characteristics.
- Business background module on business types, energy usage, etc.
- Public facility module on public facility type, staff and client numbers, etc.

A second survey instrument was developed to collect primary data on stove acquisition and ownership, fuel sources and collection/purchase practices as well as time spent collecting fuel, meal and non-meal stove uses, stove stacking, stove-use preferences and location, cooking and total expenditure, gender of person cooking and making purchasing decisions, and barriers to preferred stove and fuel use. These data were obtained for residential and non-residential respondents. Again, a single survey form was used for all respondent types, with nested questions to guide enumerators based upon responses from the survey respondents.

The survey instruments were developed in XLSForm format for conversion into XML. The data collection platform is Open Data Kit (ODK). Completed XML forms will be uploaded to an ODK Central Server on a regular basis depending on internet connectivity.

English versions of the survey instruments, in PDF format, are presented in Annex A.

Sampling Methodology Overview

The energy expenditure survey was conducted on a sampled basis in selected mini-grid project service areas in northern, central and southern zones of Madagascar. The survey was designed to employ random sampling to identify specific enumeration targets through which enumeration team members were guided to administer the questionnaire to survey participants. The questionnaire was designed to collect data regarding sources of fuels, energy services and expenditure by type of service including lighting, mobile phone charging, entertainment, productive use of energy (PUE) and cooking. Responses were recorded on GPS-enabled tablets. A team of enumerators was hired and trained to conduct the survey at the randomly selected households and businesses for each of the three survey areas. The enumerators were hired by AIDES (a Malagasy consulting and survey firm) and trained by the NRECA survey specialist. The survey forms were developed and programmed into ODK, which allows for multiple question types and languages. The surveys were developed in French, while enumerators communicated in Malagasy as required.

The sampling methodology was a two-stage purposeful sample. The selection process began with coordination with the Agency for the Development of Rural Electrification (ADER) to review the population and distribution of all private mini-grid sites operating in Madagascar. The mini-grids were divided into southern, central and northern zones to ensure geographic diversity in

the survey process. The mini-grids were then divided by technology – solar PV mini-grids and hydroelectric mini-grids; a decision was reached to ensure that the sampling frame would include surveys for both generation technologies. The population of mini-grids was also classified by service provider, and in addition to ensuring that the sample included representation by both solar and hydro generation technologies, SEforALL and NRECA also determined that the survey sample should include representation from the two largest mini-grid providers; WeLight and ANKA. Lastly, selection of the survey areas required that the survey team could complete the survey within a given timeframe, so the final site selection discarded sites in more remote and less accessible areas of Madagascar. Using these criteria, NRECA proposed the final analysis of sites and selection of survey areas to SEforALL and ADER and a final selection was completed.

Once the sites had been selected, a second stage of sampling was undertaken for each survey area to create the final sampling frame for four categories of respondents – electrified/unelectrified residential respondents and electrified/unelectrified commercial and institutional respondents. NRECA proposed that each sample contain approximately 350 households and 100 non-households (commercial and institutional enterprises) per sampling frame¹. This sample size was split evenly between the electrified mini-grid area and non-electrified area to proportionally sample respondents. That is, the survey sample included 175 electrified area and 175 non-electrified area residential survey respondents for each sampling frame, as well as 50 electrified area and 50 non-electrified area non-household survey respondents. A sample size calculator² was used to define the sample size target of up to 350 household surveys for each sampling frame. This was an estimate based on a maximum household population of 4,000 per site, with a 5 percent margin of error and 95 percent confidence level.

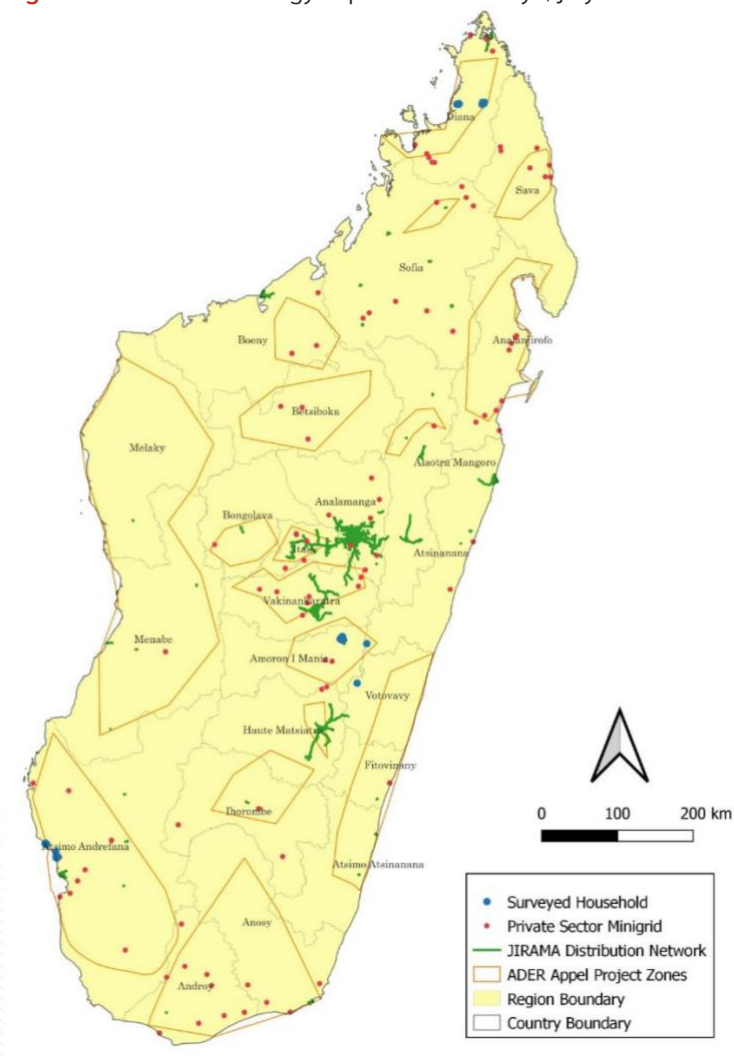
To randomly select survey respondents, the GIS database of structures was used to sample structure points to complete the required sample size plus a margin of additional survey sites to account for unoccupied structures and non-available respondents. In addition to the randomized structures, the survey team also used purposeful sampling for unelectrified non-residential structures. In each mini-grid service area sampled, the approach was to create a simple random sample that targets respondents – both households and small business owners – who receive electricity from the mini-grid and those who are not connected.

Table 1 shows the balance of mini-grid consumers and unelectrified households surveyed in each of the three zones the energy expenditure survey was undertaken.

Table 1. Samples completed per sample frame

Zone	Mini-grid	Electrified Households	Unelectrified Households	Total Households	Electrified Businesses and Public Facilities	Unelectrified Businesses and Public Facilities	Total Bus & Public Facilities
North	WeLight	180	180	360	55	55	110
Central	HEIR	180	180	360	55	57	112
South	ANKA and Manombo Sub	176	180	356	55	54	109
Total		536	540	1076	165	166	331

While the results of the energy expenditure surveys provided valuable data on energy usage and spending patterns, due to limitations of funding and time, the survey sample was limited to three zones and five sites. Projecting the results to all regions in Madagascar should be undertaken with caution.

Figure 1. Location of energy expenditure surveys, July 2023

Sampled respondents

The following discussion presents definitions of the respondents sampled and the sampling selection.

Households

Definition of household: A group of individuals who comprise a family unit, sometimes encompassing domestic help, and who live together under the same roof.

A combination of geographic randomization and purposeful sampling was used to create a geographically referenced sample. The GIS survey team enumerated all structures that were included in the sample frame and a two-stage stratified randomized sampling methodology was used to select the sampled households using a randomization tool in QGIS. This included the following steps:

1. The GIS team digitized all structures within the geographic limits of the mini-grid service areas selected for primary data collection. The structures were stored as a point-based layer, where each point represents a structure. After digitization, all structures were enumerated.
2. Recognizing that different zones of each town may have varying consumption levels, each town was divided into four areas using visual breaks in settlement clusters to define the area.
3. Using the total sample size as a guide, but allowing for oversampling, individual sample sizes for each area were assigned and a random sample was performed for each area. This was performed using a tool in QGIS named “Random Selection.”
4. The randomized sample represented the selection of households that were included in the survey – allowing for oversampling as discussed above. Each sample household was assigned a unique identifier called a premise ID. The selected households were stored in a file that was uploaded onto the tablet platform. Enumerators were assigned selected households daily to be included in the survey and the tablet platform allowed the enumerators to navigate directly to these randomly selected households.
5. Oversampling allowed enumerators to discard structures that were not residential, that were unoccupied or for which inhabitants were not present or cooperative. Once the allocated sample was achieved in each region, the survey team moved to the next area.
6. The team surveyed up to 350 households in each town and not more than 400. Enumerators were expected to survey eight to ten households per day; six enumerators were assigned to the residential survey.

Small businesses and public institutions

Definition of a small business and public institution for sample selection: Small commercial enterprises are those structures whose primary purpose is to conduct income-generating activities or to provide a public service. They include health clinics, schools and public administration offices.

Purposeful sampling was used to create a geographically referenced sample. The following steps were taken:

1. To complete the sample of small businesses and public institutions, the team purposefully selected small businesses for inclusion in the sample within each mini-grid service area selected. The field supervisor and commercial enumerators began by estimating the total number of small businesses and public institutions in the zone. This estimation was then used to evaluate the skip count that was used to select businesses for the survey. That is, the estimated total number of small businesses and public institutions was divided by the number of samples required to set the skip between surveyed businesses.
2. The enumeration team then performed the survey. A team of two enumerators were engaged in this survey.

SURVEY IMPLEMENTATION

This section presents an overview of the survey implementation process, methodology and tools that were needed. The following topics are summarized:

- Logistics and supplies
- Field staff recruitment, training, and testing
- Field survey implementation
- Data management and analysis

Logistics and supplies

Mobile Technology/Applications

As the tablet served as the central piece of equipment for the survey, the applications (apps) loaded onto the tablets similarly served as key components of the survey's implementation. ODK was available at the Google Play Store at no cost.

The apps that were installed and available for use included:

- ODK – Links: [Website](#) and [Google Play Store](#)
- Google Docs – to store the enumerator training manual
- Integrated calculator and camera applications.

Open Data Kit Collect

ODK Collect was the primary app used for the survey. It was downloaded on all tablets with a blank survey questionnaire from the ODK server. Multiple questionnaires were filled in by enumerators in the field that were then uploaded to the server when completed. ODK Collect is intuitive and easy to use, and it supports multiple languages, with the ability to quickly change the language of the survey on the fly. In addition, ODK Collect now allows for map views, such

that NRECA could preload a tile base map of the sample structures each enumerator was to visit and survey. An example of this is shown in Figure 2.

Figure 2. *Satellite tiles loaded onto a tablet with structures sampled for the survey.*



Other tablet applications

A variety of other apps were used during the survey, such as:

- A QR code reader in conjunction with each enumerator's ID badge, which featured the enumerator's ID number in QR code form. This allowed the enumerator to directly scan in their ID code and reduced the risk of an enumerator incorrectly entering their ID number.
- Google Sheets, where the survey training guide was loaded, as well as a document outlining the survey's targets, contact/emergency numbers, etc.
- A camera for the enumerator to take pictures of important features of a household's energy usage profile that might be hard to detail within the survey form. For example, the enumerator could take a picture of the respondent's electric meter, the nameplate of a generator that was hard to decipher, the type of bottle used to hold a local measure of kerosene, etc.
- A calculator to make field calculations when needed.

Enumerator tools

The primary tool enumerators required was a tablet computer programmed to assist in surveyed household selection and loaded with the survey instrument. In addition, the enumerators were provided with:

- Authorization letters from ADER stating the purpose of the survey and authorizing its implementation
- Identification badges (with QR codes representing their enumerator number)
- Simple survey uniforms (shirts or caps) to easily identify survey team members
- Mobile power banks to recharge tablets while in the field
- Small notepad and pen. These were not necessary, but were preferred by some enumerators

Recruitment, training of field staff and pilot

NRECA hired AIDES (a Malagasy survey firm (<http://www.aides-mada.com/>)) to draw up a list of candidates who it then interviewed. A team of eight were selected for training, with efforts made to achieve gender balance. When selecting enumerators and supervisors, NRECA considered previous experience with censuses and surveys, ability to manipulate the technology employed, communication skills and willingness to travel and stay at the field location for extended periods of time, often under difficult conditions.

NRECA conducted a two-day training involving all enumerators. The training covered:

- Background and objectives of the survey and project
- Presentation and exercises covering key survey terms and principles
- Reading the questionnaire aloud (paper format), allowing interjections to make clarifications and some modifications
- Use of the tablets
- Use of ODK on the tablets
- Second reading of the questionnaire in ODK, testing all answers and allowing interjections to make clarifications and some modifications
- Self-interview and testing (in groups of two, each conducting their own interview)
- Presentation and exercises on the use of the mobile GIS app used during the survey
- Presentation on supervision and enumerator responsibilities regarding data quality
- Presentation on field logistics
- Review of ODK and GIS/sample use in field, questions on survey form
- Review of necessary protocol activities (if needed)

A field pilot survey was also conducted in Mahitsy, a rural urban community about 45 km from Antananarivo. All enumerators and supervisors participated, completing a designated half-day

quota of surveys. After the field test, NRECA reviewed the pilot results and decided on the selection of enumerators to participate in the survey. Using a team of eight enumerators, NRECA completed the field survey in 21 days not counting travel days or days required for training and testing.

Data management and analysis

NRECA employed multiple data management and quality methods, including: 1) review of survey forms at the completion of each survey day; 2) tracking and enumerator supervision; and 3) daily download and review of the database. These are discussed in brief below.

Form Checking

At the end of each day, the supervisor checked the finalized forms on each tablet before the data were uploaded to the ODK central server. The review process provided an opportunity to review the raw data collected, discuss any discrepancies and flag any issues that may have required the enumerator to return to the respondent to seek further clarification. Common issues for the supervisor to keep in mind included typos, numerical errors including orders of magnitude of reported consumption or energy usage, skipped sections, etc.

Tracking and Enumerator Supervision

The enumerators were tracked using the ODK Collect app, and these data were reviewed on the tablet of each enumerator at the end of each survey day. Any issues were immediately discussed with the enumerator in question. In addition, the tracking data could also be exported from the tablet and reviewed and stored by the supervisor on their laptop.

Data Quality and Cleaning

Using the ODK central server, NRECA produced intermediate copies of the survey database for review periodically. The supervisory team then reviewed the data for potential errors and flagged any identifiable issues for correction.

RESULTS

The results of the energy expenditure and clean cooking survey are reported by zone and by respondent type in the sections below.

Energy Survey Results

This section provides descriptive statistics on the use of energy and electricity by the surveyed households and small commercial and public facilities in each of the three surveyed zones in Madagascar. Specifically, it provides analyses of the demographic characterization of households, followed by an analysis of energy usage and expenditure by households and small commercial and public facilities.

Household Demographic Characteristics

The questionnaire included questions used to establish the characteristics of the households surveyed such as ownership status, access to potable water, types of toilet facilities used and demographic information regarding family size, gender of heads of households, the average hours spent on household chores per day and the primary source of income for the households. Responses to these questions were meant to help contextualize income and expenditure data and to understand people's living conditions as well as provide useful insights to understand gender dimensions across the zones in Madagascar.

Table 2 shows that most residents in all three zones own the house they are living in. Ownership is slightly higher in the northern zone (90 percent) and lowest in the central zone (77 percent).

Table 2. House ownership (%)

Ownership Status	Central (%)	Southern (%)	Northern (%)
Owned	77%	80%	90%
Rented, subsidized or free	23%	20%	10%

The households surveyed use a variety of different types of toilet facilities, which vary across the three surveyed zones as shown in Table 3. For example, uncovered pit latrines are the most common type of toilet in the central and southern zones. The central zone recorded the highest usage by population (58.6 percent) of uncovered pit latrines, slightly higher than the southern zone (43.5 percent). In the northern zone uncovered pit latrines are the second most-used toilet facilities (6.35 percent). The table also shows that most households in the northern zone (87.5 percent) have no toilet facilities, which suggests open defecation. Open field is also the second most prevalent sanitation modality in the southern zone, representing 28.7 percent of respondents.

The results also show that community latrines and other non-specified toilet types are used by only a small proportion of households. In general, -the three zones are not making significant improvement in sanitation because households use either uncovered pit latrines or no toilet

facilities at all (open field), thereby increasing the amount of human waste contamination in the environment.

Table 3. Distribution of types of toilet facilities used by households (%)

Toilet facility type	Central (%)	Southern (%)	Northern (%)
Community latrine	10	5.5	0.8
Covered pit latrine	12.2	8.3	1.1
Flush to septic tank	2.7	8.3	1.3
Flush to sewage	14.1	5.3	2.4
Uncovered pit latrine	58.6	43.5	6.3
Others non-specified	0	0	0.2
None (open field)	2.2	28.7	87.5

Table 4 provides an analysis of the sources of drinking water used by the households surveyed. Sources of drinking water vary significantly across the zones. The results indicate that the most common source of drinking water for households in the central zone is treated pipe-borne water (31.1 percent of respondents). Unprotected wells and/or springs account for more than 50 percent of drinking water for the households in the northern and southern zones, and water from protected wells/springs is the second most common source of drinking water in the southern (31.7 percent) and northern (31.3 percent) zones.

Table 4. Distribution of sources of drinking water used by households (%)

Drinking water source	Central (%)	Southern (%)	Northern (%)
Pipe borne water, treated	31.1	9.2	0.2
Pipe borne water, untreated	9.7	0.0	0.0
Electric water pump	10.2	5.3	0.0
Lake/reservoir	0.2	0.0	0.0
River/spring	0.2	0.0	0.2
Borehole with hand pump	0.0	1.4	0.0
Well/spring protected	21.3	31.7	31.3
Well/spring unprotected	26.9	52.2	68.0

Household size (number of family members living in each house) does not vary significantly across the zones as shown in Table 5. In the central and northern zones, the largest percentage of families are those made up of four people, representing 24.1 percent and 22.5 percent of households, respectively. In the southern zone, the largest share of families (19.3 percent) is made up of households with three occupants.

Table 5. Household size by zone

Size of Household (persons)	Central (N=360)		South (N=356)		North (N=360)	
	Count	Percentage (%)	Count	Percentage (%)	Count	Percentage (%)
1	24	6.67	24	6.74	20	5.56
2	50	13.89	39	10.96	49	13.61
3	68	18.89	69	19.38	67	18.61
4	87	24.17	63	17.70	81	22.50
5	57	15.83	54	15.17	57	15.83
6	45	12.50	45	12.64	38	10.56
7	13	3.61	28	7.87	21	5.83
8	9	2.50	16	4.49	16	4.44
9	3	0.83	7	1.97	3	0.83
>=10	4	1.11	11	3.09	8	2.22

Figure 2 presents the distribution of male- and female-headed households, which is relatively consistent across all zones. In the central and southern zones, 76.4 percent and 82.3 percent of households, respectively, are headed by males, while in the northern zone 84.7 percent of all surveyed households are headed by males.

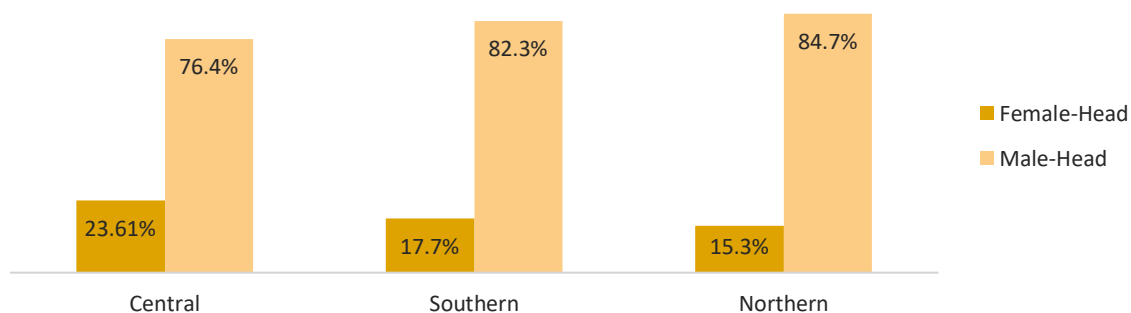
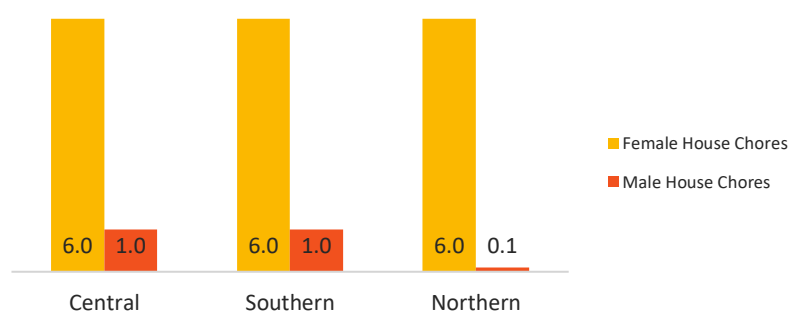
Figure 2. Distribution of male- and female-headed households by zone (%)

Figure 3 shows that the average time spent by males and females on household chores is consistent across the zones; female members of the household spend an average of six hours a day on household chores whilst their male counterparts spend an hour or less.

Figure 3. Distribution of average time spent by males and females on household chores (hours)

Farming (growing and selling crops) is the main source of income for the largest share of households in the northern zone – 37.2 percent of respondents. 11.9 percent of respondents stated that ownership of a business was their primary source of income. 19.2 percent and 32.4 percent of households in the central and southern zones, respectively, derive their main source of income from other sources and 16.2 percent and 27.6 percent of households in the central and southern zones, respectively, stated that wages paid for non-farming labour were their main source of income.

Table 6. Distribution of the primary source of household income (%)

Primary Source of income	Central	South	North
Wages paid for agricultural labour	3.91	1.13	3.33
Ownership of a business	12.85	15.54	11.94
Farming (growing and selling crops)	15.64	7.91	37.22
Government payments (pension, veteran's benefits)	8.10	2.82	1.11
Raising or selling livestock/livestock products	4.75	1.69	0.83
Payment for professional services (teacher, health care, entertainment)	12.29	7.91	6.94
Remittances from relatives working away from home	2.51	1.13	0.28
Income from rental of property or livestock	1.68	0.56	0.0
Wages paid for other labour	16.20	27.68	0.0
Other	19.27	32.49	6.67
None	2.79	1.13	0.0

Business Characteristics

As observed in Table 7 the primary activity of the businesses in each zone varies slightly. The predominant businesses are restaurants, small grocery stores and other sales activities.

Table 7. Distribution of the primary activity of the business (%)

Primary Activity of Business	Central	South	North
Bakery or butchery	2.97	0.85	0.69
Blacksmith or welding	1.98	0.85	2.08
Carpentry, furniture making	2.97	1.71	0.69
Computer/internet	0.99	2.56	1.39
Dry goods (clothes, office supplies etc)	3.96	3.42	8.33
Drying fish	0.0	0.0	0.69
Food and drink (not restaurant)	3.96	16.24	15.28
Grain or corn milling	0.0	0.0	2.08
Small grocer	13.86	35.04	32.64
Hair salon/barber	1.98	4.27	2.08
Handicrafts	1.98	0.85	1.39
Hardware	3.96	0.85	5.56
Lumber or sawmill	0.0	0.0	0.69
Mechanical repair (cars, bicycles)	2.97	0.85	1.39
Mobile phone charging	2.97	1.71	1.39
Other activities (mobile money or credit transfer, shoemaker/repairer, counter medicine shops)	15.84	5.13	6.94
Other sales	10.89	9.40	7.64
Restaurant/café	22.77	10.26	8.33
Seamstress/tailor	0.99	1.71	0.69
Charcoal	0.0	0.85	0.0
Hotel	0.0	2.56	0.0
Photocopying	0.99	0.85	0.0
Electronics repair	0.99	0.0	0.0
Livestock raising or breeding (goats, cows, pigs)	1.98	0.0	0.0
Other agricultural or livestock production	0.99	0.0	0.0
Total	100%	100%	100%

Table 8 shows the ownership and operation of businesses by gender.

Table 8. Distribution of businesses ownership and operation by gender (%)

Gender	Central (%)	South (%)	North (%)
Ownership			
Owned by males	38	43	64
Owned by females	45	37	33
Operation			
Operated by males	30	33	49
Operated by females	53	48	48

Table 9 shows how many businesses use electrical appliances or electric lighting regularly. Businesses in the northern zones regularly use more electrical appliances and lighting than those in the northern and southern zones.

Table 9. Business usage of electrical appliances or electric lighting (%)

Responses	Central (%)	South (%)	North (%)
Yes	87%	83%	96.8%
No	13%	16.8%	3.13%

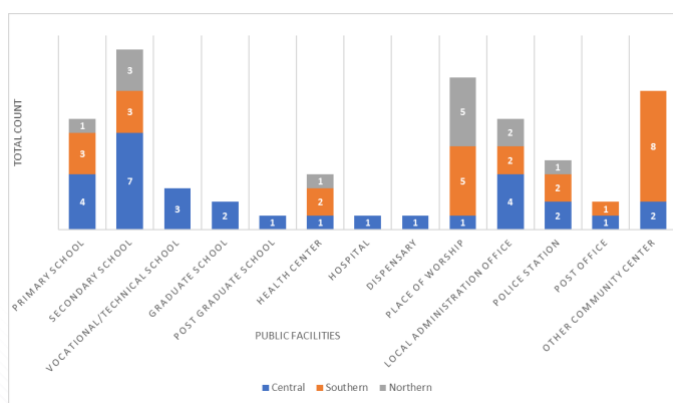
Table 10 shows the uses and applications powered by electricity in the sampled businesses. Mobile phone charging and lighting were the main activities that electricity was used for across the zones.

Table 10. Business usage of electricity (%)

Usage of Electricity	Central (%)	South (%)	North (%)
Computer	1.32	2.99	2.82
Food blender or mixer	0.66	2.40	0.0
Freezer or ice maker	1.97	6.59	5.16
Lighting	36.18	35.93	37.56
Machinery such as saws, drills, welding equipment	0.66	1.80	2.35
Mobile phone charger	34.87	26.35	28.17
Other	7.89	5.39	2.82
Radio	10.53	8.38	11.27
Refrigerator	1.97	5.39	0.94
Television	2.63	4.79	4.69
Electric fan	1.32	0.0	0.94
Grain mill	0.0	0.0	3.29

Public Facility Characteristics

Figure 6 shows the various types of public facilities and institutions surveyed across the three zones.

Figure 6. Distribution of the types of public facility or institutions surveyed

Distribution of the types of public facility or institutions surveyed

Facility type	Central	South	North
Primary School	13%	12%	8%
Secondary School	23%	12%	23%
Vocational/Technical School	10%	0%	0%
Graduate School	7%	0%	0%
Post Graduate School	3%	0%	0%
Health Centre	3%	8%	8%
Hospital	3%	0%	0%
Pharmacy	3%	0%	0%
Place of Worship	3%	19%	38%
Local Administration Office	13%	8%	15%
Police Station	7%	8%	8%
Post Office	3%	4%	0%
Other Community Centre	7%	31%	0%
Total Public Facilities	30	26	13

Table 11 shows the number of years each facility has been operating at its present location.

Table 11. Number of years of facility in operation at its present location

Number of Years	Central		South		North	
	Count	Percentage (%)	Count	Percentage (%)	Count	Percentage (%)
5 years or less	3	10.71	5	20.0	4	30.77
5 to 10 years	3	10.71	1	4.0	0	0.0
10 to 15 years	1	3.57	1	4.0	1	7.69
15 to 20 years	4	14.29	6	24.0	2	15.38
20 years or more	17	60.71	12	48.0	6	46.15

Table 12 summarizes the distribution of the primary sources of electricity in the facilities surveyed by zone. Note that the source of electricity varies across the zones.

Table 12. Primary source of electricity in the facilities

Source	Central		South		North	
	Count	Percentage (%)	Count	Percentage (%)	Count	Percentage (%)
Local mini-grid	24	85.71	14	53.85	7	53.85
Generator	1	3.57	0	0.0	0	0.0
Solar PV system	0	0.0	5	19.23	2	15.38
Solar lighting system	1	3.57	1	3.85	2	15.38
Solar lantern	0	0.0	2	7.69	0	0.0
Rechargeable battery system	0	0.0	0	0.0	1	7.69
No electricity	2	7.14	4	15.38	1	7.69
Total	28	100%	26	100%	13	100%

Energy Uses and Sources

The energy expenditure modules in the survey instrument were designed to capture a clear and comprehensive picture of multiple fuel and energy sources purchased by each participant; the amount spent on each fuel type on the temporal basis for which each energy source was purchased (daily, multi-daily, monthly or another period); the purpose for which each fuel or energy source was purchased (lighting, communication, entertainment, income generation, other) as well as a comprehensive survey of appliances owned and used by each surveyed household and business.

As observed in Table 13, candles of any size are not commonly used as a fuel source in households in any of the zones. When candles are used, medium-sized ones are most commonly used. Electrified households in the central zone (8.8 percent) reported using more medium-sized candles than electrified households in the southern zone (6.8 percent) and unelectrified

households in the central and southern zones reported usage of 2.7 percent and 2.2 percent, respectively. In the northern zone, 2.2 percent of electrified households and 2.7 percent of unelectrified households reported using small candles.

Kerosene usage for lighting was more widely reported among unelectrified households (38.8 percent) in the central zone compared to unelectrified and electrified households in the southern zone, 6.59 percent and 2.27 percent, respectively. Gasoline usage was reported only in unelectrified households in the northern zone.

Table 13. Household usage of fuel for lighting (%)

Source	Central (%) (N=360)		South (%) (N=356)		North (%) (N=360)	
	Electrified	Unelectrified	Electrified	Unelectrified	Electrified	Unelectrified
Candles (small)	0.5	0.0	1.7	1.6	2.2	2.7
Candles (medium)	8.8	2.7	6.8	2.2	0.0	0.0
Candles (large)	0.0	2.2	0.0	0.0	0.0	0.0
Diesel	0.0	0.0	0.0	0.0	0.0	0.0
Gasoline	0.0	0.0	0.0	0.0	0.0	4.4
Kerosene	0.0	38.8	2.2	6.5	0.0	0.0

Table 14 shows households' access and usage of electricity by source. Most households that are electrified have a direct connection from mini-grid operators. The central zone has a slightly greater share (89 percent) of electrified households than the northern and southern zones where 86.6 percent and 79.3 percent, of households, respectively, are connected. In the southern zone households were more likely to use electricity supplied to a neighbour (10.8 percent) than those in the central and northern zones (9.2 percent and 5.6 percent, respectively).

Various photovoltaic (PV) systems are commonly used in households across the zones specifically among unelectrified households. The most common category of solar PV systems reported are small standalone solar systems (SSS) that come with one small panel, lamps and a socket. They are used for lighting, small radios and mobile phone charging. 27.62 percent of unelectrified residential consumers in the southern zone, 24.59 percent of those in the central zone and 35.33 percent of those in the northern zone reported relying on small SSS as their primary source of electricity.

The use of medium SSS is also common among residential consumers. Medium SSS comes with one larger panel, lights and sockets and can power small appliances such as a radio or a fan. 18.48 percent of unelectrified households in the northern zone use medium-sized SSS as compared to 9.94 percent in the southern and 14.21 percent in the central zones, respectively.

The high usage of small and medium SSS by unelectrified households is because that is the only alternative source of electricity available to them. None of the households reported using a

generator, which is consistent with diesel not being reported as a fuel type used among households in the survey responses.

Table 14. Household usage of electricity by source (%)

Source	Central (N=360)		South (N=356)		North (N=360)	
	Electrified	Unelectrified	Electrified	Unelectrified	Electrified	Unelectrified
Distribution Mini-Grid Overall						
Electricity from local utility	89.07	0.0	79.38	0.0	86.67	0.0
Electricity from a neighbour	9.29	0.0	10.82	0.0	5.64	0.0
PV overall						
Lighting from a solar lantern	0.55	6.01	0.52	3.31	4.10	2.17
Small SSS	1.09	24.59	4.12	27.62	1.03	35.33
Medium SSS	0.0	14.21	3.09	9.94	2.56	18.48
Roof-mounted PV system	0.0	0.0	1.55	0.0	0.0	1.63

The most common batteries used by households in the survey are those used to charge cellphones, which is consistent with the ownership of cellphones as reported in the survey data. Note that the batteries used in solar PV systems are not counted in this section. Approximately 21.3 percent of unelectrified households in the central zone, 29.7 percent of households in the southern zone and 25.6 percent of households in the northern zone use AA batteries.

Table 15. Household usage of batteries by type (%)

Source	Centre (%) (N=360)		South (%) (N=356)		North (%) (N=360)	
	Electrified	Unelectrified	Electrified	Unelectrified	Electrified	Unelectrified
AA	1.4	21.3	7.3	29.7	6.67	25.6
AAA	5.4	0.7	18.6	10.7	3.33	0.3
Type C	0.4	5.6	0.0	1.1	0.0	0.3
Type D	0.0	0.0	0.0	0.3	0.0	0.3
Rechargeable AA	0.0	0.0	1.4	0.3	0.48	0.0
Rechargeable AAA	0.0	0.0	0.3	0.0	0.0	0.0
Rechargeable C	0.4	0.0	1.1	0.0	0.0	0.0
Rechargeable D	0.0	0.7	1.1	0.3	0.0	1.0
Lead small	0.0	10.6	1.4	9.6	0.95	16.1
Lead medium	0.0	8.9	2.9	4.4	2.38	11.2
Lead large	0.0	0.0	0.7	0.0	0.0	0.0
Small lithium battery- cellphone battery	85.2	38.7	58.6	34.2	81.43	35.7
Medium lithium battery- tablet battery	0.49	0.3	2.5	0.0	0.48	0.0
Large lithium battery- laptop battery	3.45	0.0	1.4	0.3	0.48	0.0
Other rechargeable battery	0.0	3.9	0.3	3.7	0.4	5.9

As seen in Table 16, the main sources of energy used by commercial and public respondents are solar PV systems and rechargeable batteries. The use of candles as a source of energy was minimal among these respondents. Diesel fuel usage for electric generators was reported among unelectrified respondents in the northern zone, and kerosene usage was only reported among unelectrified respondents in the central zone.

Table 16. Energy usage of commercial and public facilities by source

Non-cooking energy source	Central Electrified (%)	Central Unelectrified (%)	Southern Electrified (%)	Southern Unelectrified (%)	Northern Electrified (%)	Northern Unelectrified (%)
Fuels						
Kerosene	0.0	2.3	0.0	0.0	0.0	0.0
Diesel	1.5	0.0	0.0	0.0	1.7	5.6
Gasoline	0.0	0.0	0.7	0.0	0.0	0.0
Candles	0.0	1.1	0.7	0.81	0.0	0.0
Generators overall						
Small generators	0.0	0.0	0.0	0.0	0.8	1.4
Medium generators (1.51kW to 20 kW)	0.7	0.0	0.0	0.0	0.0	4.2
Large generators	0.7	0.0	0.0	0.0	1.7	0.0
Solar PV systems overall						
Small SSS - one smaller panel, lamps and socket	0.0	5.8	0.7	7.2	0.0	11.2
Medium SSS - one larger panel, lights, sockets	0.0	1.1	1.4	11.2	0.0	4.9
Roof-mounted PV system - more than 1 panel, lights, sockets,	0.7	1.1	3.6	4.0	2.6	2.1
Lighting from a solar PV lantern (<3W)	0.0	11.7	0.7	3.2	0.8	6.3
Electricity from utility	39.2	0.0	38.8	0.0	46.4	0.0
Electricity from neighbour	3.0	0.0	0.7	0.0	2.6	0.0
Batteries						
Rechargeable batteries	52.3	64.7	48.9	61.2	41.9	51.4
Non-rechargeable batteries	1.5	11.7	3.6	12.1	0.8	12.6
Total	100%	100%	100%	100%	100%	100%

Appliance Use Patterns

Table 17 provides a summary of the range of electrical appliances used by the sampled households. The data show that mobile phones with chargers, LED bulbs, LED torches and radios and/or music players were the most common appliances. Unsurprisingly, electrified households use more appliances than unelectrified households.

Table 17. Household appliance usage (%)

Types of Appliances	Central Electrified	Central Unelectrified	Southern Electrified	Southern Unelectrified	Northern Electrified	Northern Unelectrified
Mobile phone with charger	25.26	34.70	25.28	29.93	27.78	31.99
CFL lights bulbs	0.15	0.95	0.0	1.32	0.33	0.31
Desktop computer	0.44	0.0	0.0	0.0	0.0	0.0
Freezer	0.44	0.0	1.11	0.0	1.47	0.0
Hair dryer	0.30	0.0	0.16	0.0	0.0	0.0
Incandescent light bulbs	0.15	0.32	0.32	0.0	0.0	0.0
Incandescent torch	0.0	0.0	1.11	0.0	0.0	0.0
Iron	3.25	0.0	0.64	0.0	0.16	0.0
Laptop	2.36	0.0	1.59	0.33	0.33	0.0
LED light bulbs	26.44	19.87	27.19	13.82	29.08	28.57
LED torch	1.18	19.24	7.63	38.49	2.78	24.22
Microwave	0.30	0.0	0.16	0.0	0.0	0.0
Electric mill	0.15	0.0	0.0	0.0	0.0	0.0
Food mixer or blender	0.74	0.0	0.32	0.0	0.0	0.0
Other home appliances	0.44	0.0	0.32	0.0	0.0	0.0
Other lighting appliances	0.15	0.0	0.16	0.33	0.0	0.0
Other electric machines	0.59	0.0	0.16	0.0	0.16	0.0
Radio and/or music player	12.11	22.08	10.81	13.82	13.24	13.35
Refrigerator	1.77	0.0	1.11	0.0	0.49	0.0
Rice cooker	1.62	0.0	0.64	0.0	0.0	0.0
Satellite dish	3.99	0.0	1.75	0.0	4.08	0.0
Sewing machine	0.15	0.0	0.0	0.0	0.0	0.0
Electric soldering iron	0.15	0.0	0.0	0.0	0.0	0.0
Television (black and white)	3.25	0.32	1.59	0.0	1.31	0.0
Television (flat screen)	14.62	2.52	15.10	1.64	17.48	1.55
Electric drill	0.0	0.0	0.32	0.0	0.0	0.0
Electric fan	0.0	0.0	0.95	0.0	0.82	0.0
Electric wood planer	0.0	0.0	0.32	0.0	0.16	0.0
Projector	0.0	0.0	0.16	0.0	0.0	0.0
Refrigerator with freezer combo	0.0	0.0	0.16	0.0	0.16	0.0
Table saw	0.0	0.0	0.16	0.0	0.0	0.0
Tablet	0.0	0.0	0.32	0.0	0.16	0.0
Water pump	0.0	0.0	0.32	0.33	0.0	0.0
Electric welder	0.0	0.0	0.16	0.0	0.0	0.0

Table 18 provides a summary of the appliances used by the sampled commercial and public facility respondents. Note that mobile phones with chargers, LED bulbs, radios and/or music players make up the most common appliances reported.

Table 18. Commercial and public facility appliance usage (%)

Types of Appliances	Central Electrified	Central Unelectrified	Southern Electrified	Southern Unelectrified	Northern Electrified	Northern Unelectrified
Air compressor	0.47	0.0	0.0	0.0	0.0	0.0
Mobile phone with charger	22.33	50.0	21.23	43.14	23.13	38.53
CFL light bulbs	2.79	0.0	0.94	1.96	0.63	0.0
Desktop computer	6.51	0.0	1.42	0.98	3.13	0.0
Electric drill	1.86	0.0	0.94	0.0	1.88	0.0
ECG machine	0.47	0.0	0.0	0.0	0.0	0.0
Freezer	0.47	0.0	5.66	0.98	6.25	0.0
Hair clipper or shaving machine	0.47	0.0	0.94	0.98	0.63	0.0
Hair dryer	0.47	0.0	0.47	0.00	0.00	0.0
Handheld electric saw	0.47	0.0	0.0	0.0	0.00	0.0
Incandescent light bulbs	1.40	0.0	0.0	0.0	0.00	0.0
Laptop	6.51	0.0	4.25	0.98	2.50	0.92
LED light bulbs	20.93	7.14	23.58	19.61	27.50	22.02
Microscope	0.47	0.0	0.0	0.0	0.00	0.0
Food mixer or blender	0.93	0.0	2.36	0.0	0.00	0.0
Other electronic appliances	0.47	0.0	2.36	0.0	0.00	0.0
Other home appliances	0.93	0.0	0.47	0.0	0.00	0.0
Other lighting appliances	0.47	8.57	0.0	3.92	0.00	6.42
Other electric machines	7.44	0.0	3.77	0.0	5.63	1.83
Electric wood planer	2.33	0.0	0.47	0.0	1.25	0.0
Projector	0.93	0.0	0.94	0.0	0.00	0.0
Radio and/or music player	5.12	14.29	7.08	6.86	14.38	5.50
Refrigerator	1.40	0.0	4.25	0.0	0.63	0.0
Refrigerator with freezer combo	1.40	0.0	0.47	0.0	0.63	0.0
Refrigerator for vaccination	0.47	0.0	0.94	0.0	0.63	0.0
Satellite dish	0.93	0.0	1.89	0.0	0.63	0.0
Sewing machine	0.93	0.0	0.0	0.0	0.0	0.0
Electric soldering iron	1.86	0.0	0.47	0.0	0.0	0.0
Table saw	1.40	0.0	0.47	0.0	1.25	0.0
Tablet	1.86	0.0	1.42	0.0	0.0	0.0

Television (black and white)	0.47	0.0	0.00	0.0	0.00	0.92
Television (flat screen)	2.79	0.0	5.66	1.96	4.38	2.75
Electric welder	1.86	0.0	0.47	0.0	1.88	0.0
Wi-Fi and other networking devices	0.47	0.0	1.42	0.0	0.0	0.0
LED torch	0.0	12.86	1.42	6.86	0.63	12.84
Incandescent torch	0.0	7.14	0.94	11.76	0.0	0.92
Clock	0.0	0.0	0.94	0.0	0.0	0.00
Electric fan	0.0	0.0	1.42	0.0	1.25	0.00
Water pump	0.0	0.0	0.94	0.0	0.63	0.92
Electric mill	0.0	0.0	0.0	0.0	0.63	6.42

Energy Expenditure Results

Energy expenditure data have been historically used to evaluate electricity consumption and demand growth and to project connection rates for electrification projects. Results of energy expenditure surveys illustrate actual levels of energy use by residential, commercial and public facilities. Energy expenditure results are sometimes referred to as “revealed willingness to pay.” Survey results are used to evaluate consumption levels by decile of the served population, and thereby to project consumption of energy for the consumer population. This section of the report presents the non-cooking energy expenditure results for each surveyed zone.

Central zone energy expenditure

The energy expenditure results illustrate that electrified residential energy expenditure is higher than unelectrified residential expenditure in the central zone – as shown in Figure 4.

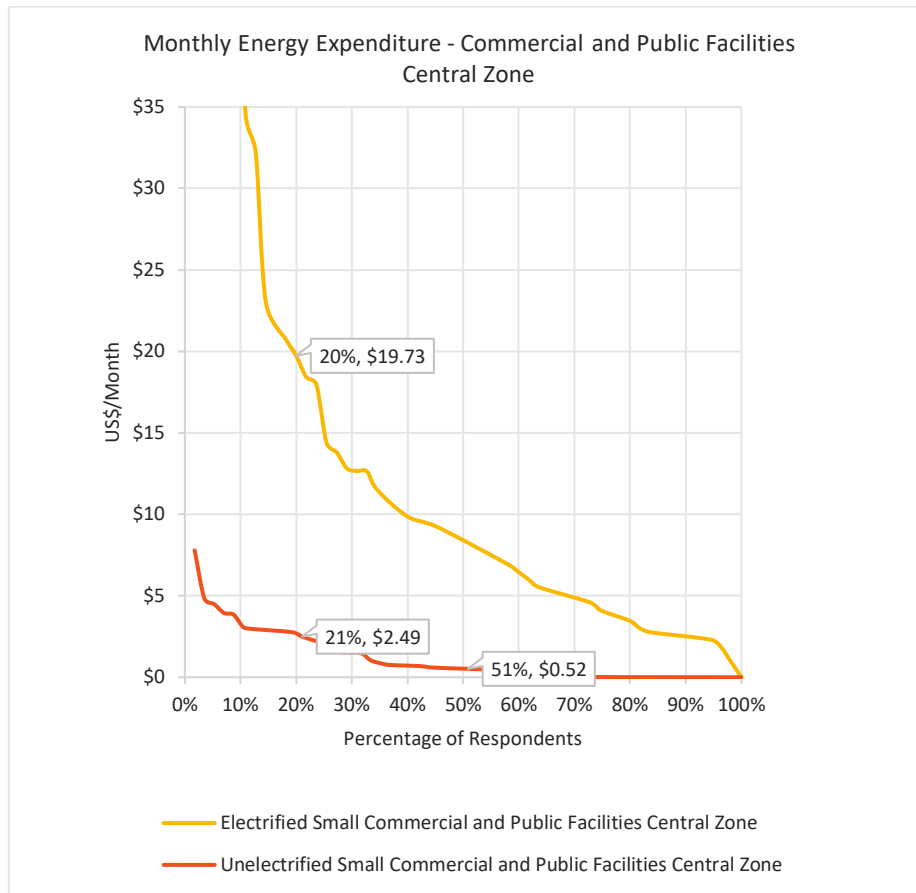
Figure 4. Monthly residential energy expenditure in central zone (USD)

Figure 5 shows that the energy expenditure of electrified commercial and public facilities is significantly higher than that of unelectrified commercial and public facilities. The expenditure of commercial and public facilities continues to widen within the higher category of respondents, for example the top 20 percent of electrified respondents spend USD 19.73 or above on energy per month, as compared to unelectrified commercial and public facility respondents only 20 percent of whom spend USD 2.65 or above on energy per month.

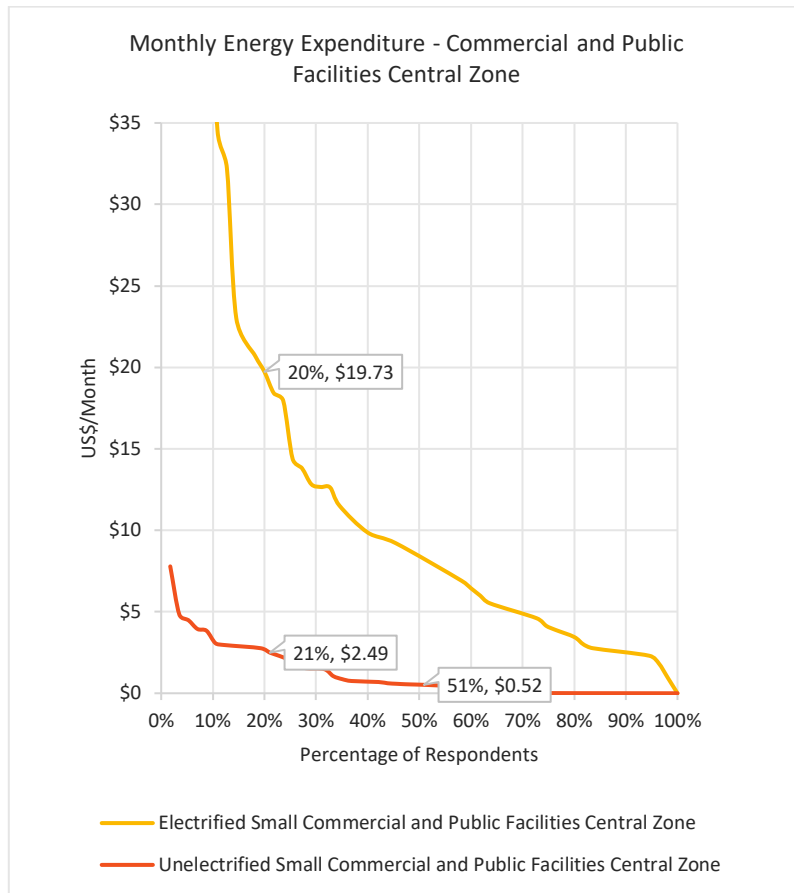
Figure 5. Monthly energy expenditure of commercial and public facilities in the central zone (USD)

Table 19 and Table 20 summarize the monthly energy expenditure by percentage of respondents for residential and commercial and public facilities sampled in the central zone. The high expenditure category corresponds to the top 20 percent of all residential and commercial consumers, while the medium category corresponds to 20 to 50 percent of the residential and commercial consumer population. The low expenditure category corresponds to the bottom 50 percent of residential and commercial consumers. Note the significant difference between electrified and unelectrified commercial and public facilities surveyed.

Table 19. Monthly energy expenditure by percentage of residential respondents in central zone

Residential	Electrified USD/Month	Unelectrified USD/Month
10%	\$ 7.37	\$5.35
20%	\$ 4.74	\$3.98
35%	\$ 3.80	\$2.88
50%	\$ 3.46	\$2.15
75%	\$ 2.43	\$1.15
90%	\$ 1.25	\$0.70

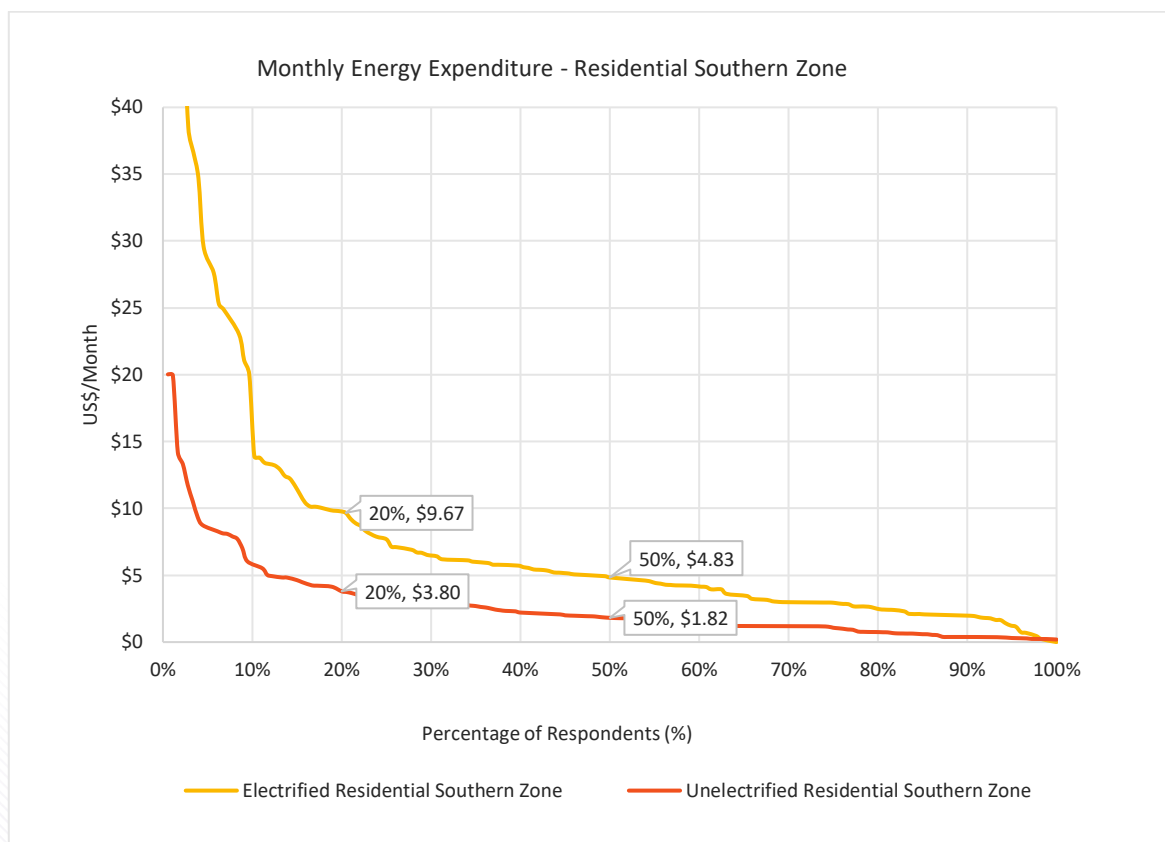
Table 20. Monthly energy expenditure by percentage of commercial and public facility respondents in central zones

Commercial and Public Facilities	Electrified USD/Month	Unelectrified USD/Month
10%	\$40.28	\$3.30
20%	\$19.73	\$2.65
35%	\$11.51	\$0.86
50%	\$8.38	\$0.53
75%	\$4.14	\$0.01
90%	\$2.49	\$0.01

Southern zone energy expenditure

Southern zone residential energy expenditure for electrified households is higher than that of unelectrified households. 50 percent of electrified household respondents spend USD 4.83 or less on energy monthly and 50 percent of the sampled unelectrified households spend USD 1.82 or less on energy monthly.

Figure 6. Monthly residential energy expenditure in southern zone (USD)



Among electrified and unelectrified commercial and public facility respondents, the analysis again shows that the energy expenditure of electrified respondents is significantly higher than that of unelectrified respondents. Figure 7 below shows that 50 percent of the electrified respondents spend USD 10 or more per month on non-cooking energy expenditure while unelectrified respondents spend USD 2.77 per month. Only the top 3 percent of respondents spend more than USD 10 per month on non-cooking energy expenditure.

Figure 7. Monthly energy expenditure of commercial and public facilities in southern zone (USD)

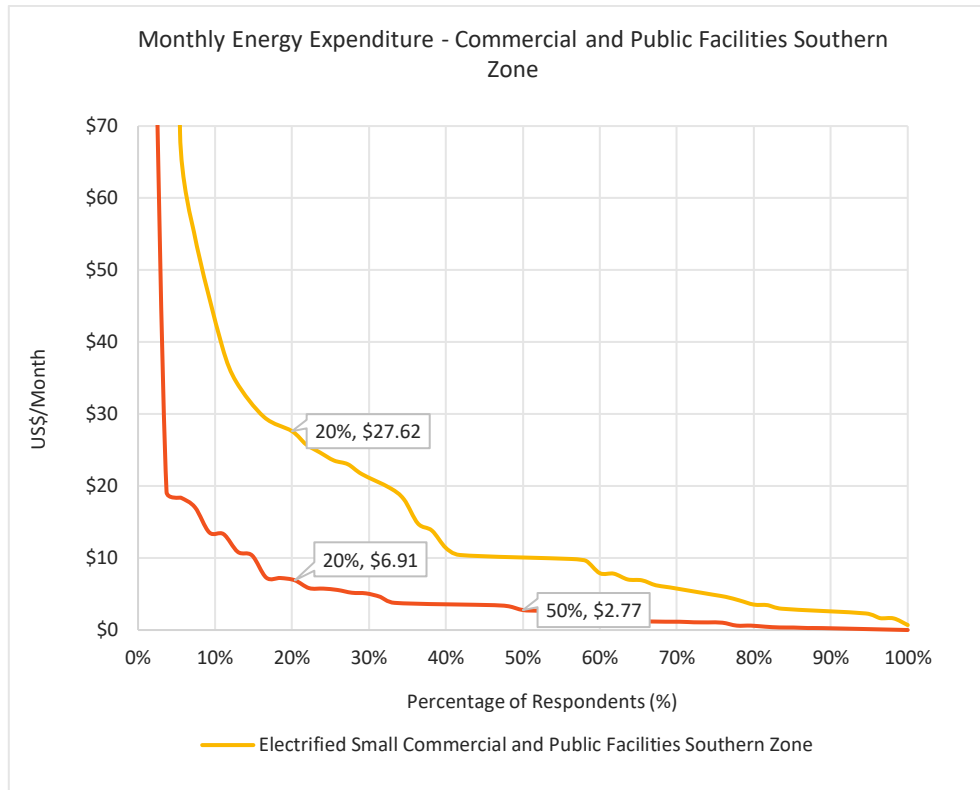


Table 21 and Table 22 summarize the monthly energy expenditure by percentage of respondents for residential and commercial and public facilities sampled in the southern zone. Again, note the differences between electrified and unelectrified monthly energy expenditure.

Table 21. Monthly energy expenditure by percentage of residential respondents in southern zone

Residential	Electrified USD/Month	Unelectrified USDMonth
10%	\$16.34	\$5.87
20%	\$9.76	\$3.80
35%	\$6.02	\$2.70
50%	\$4.83	\$1.82
75%	\$2.95	\$1.07
90%	\$1.97	\$0.38

Table 22. Monthly energy expenditure by percentage of commercial and public facility respondents in southern zone

Commercial and Public Facilities	Electrified USD/Month	Unelectrified USD/Month
10%	\$43.40	\$13.46
20%	\$27.62	\$6.91
35%	\$18.15	\$3.73
50%	\$10.11	\$2.77
75%	\$4.93	\$1.04
90%	\$2.58	\$0.24

Northern zone energy expenditure

Northern zone residential energy expenditure for electrified households is higher than that of unelectrified households. 50 percent of electrified household respondents spend USD 7.25 or less on energy monthly and 50 percent of the sampled unelectrified households spend USD 2.10 or less on energy monthly.

Figure 8. Monthly residential energy expenditure in northern zone (USD)

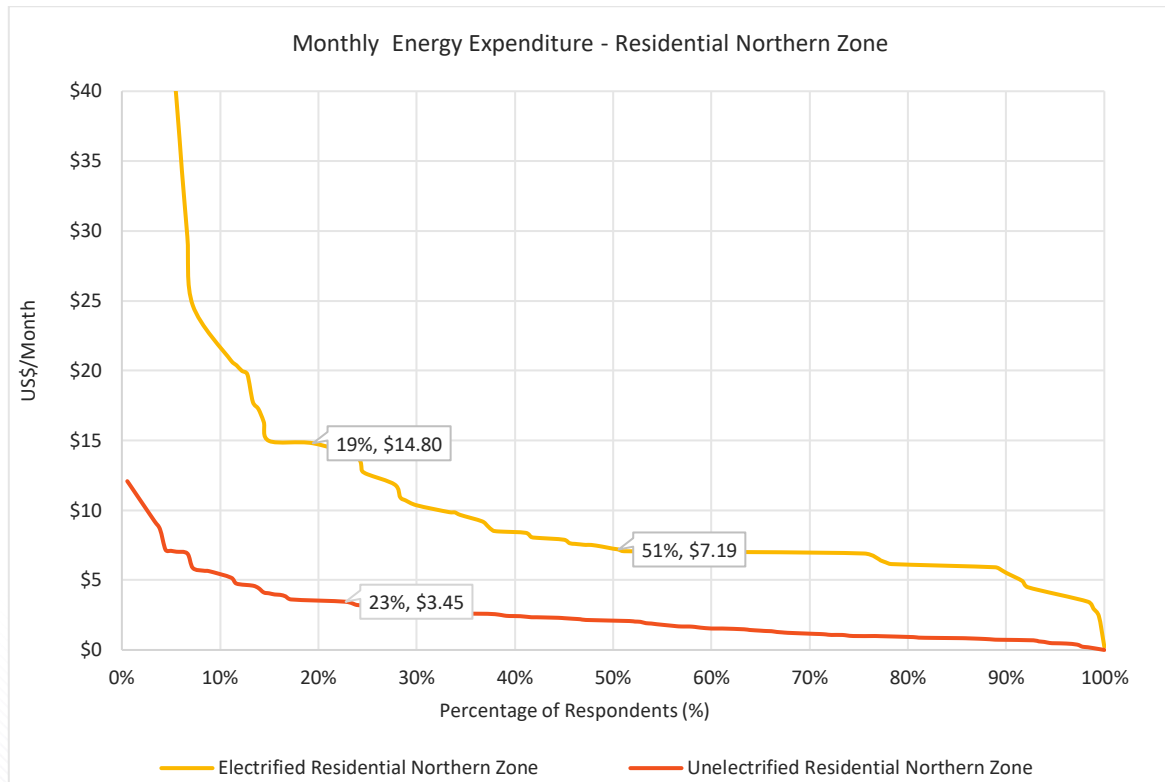


Figure 9 shows a significant gap in energy expenditure between electrified and unelectrified commercial and public facilities. 50 percent of electrified facilities spend USD 15.33 per month

on energy whereas 50 percent of unelectrified commercial and public facilities spend considerably less – USD 2.50 – per month on energy.

Figure 9. Monthly energy expenditure of commercial and public facilities in northern zone (USD)

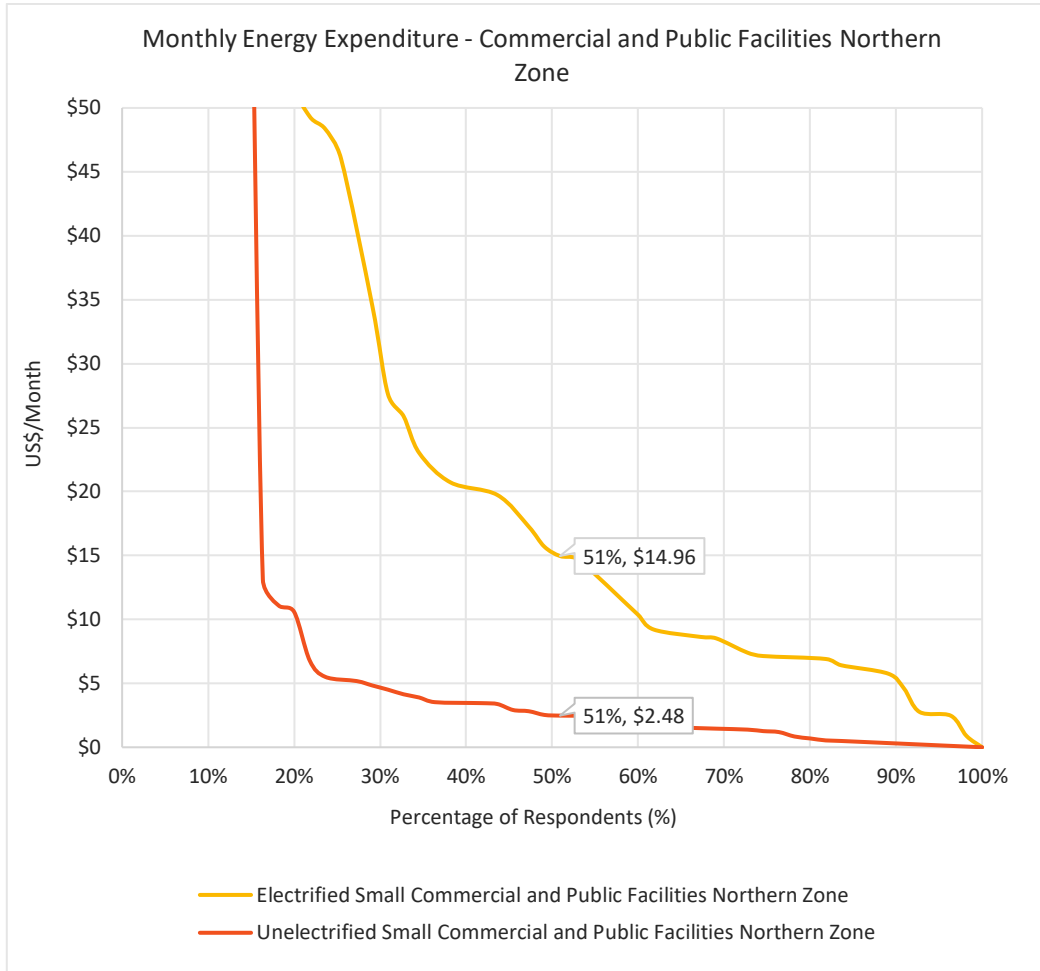


Table 23 and Table 24 summarize the monthly energy expenditure by percentage of respondents for residential and commercial and public facilities sampled in the northern zone.

Table 23. Monthly energy expenditure by percentage of residential respondents in northern zone

Residential	Electrified USD/Month	Unelectrified USD/Month
10%	\$21.84	\$5.41
20%	\$14.67	\$3.53
35%	\$9.55	\$2.61
50%	\$7.25	\$2.10
75%	\$6.91	\$1.00
90%	\$5.52	\$0.72

Table 24. Monthly energy expenditure by percentage of commercial and public facility respondents in northern zone

Commercial and Public Facilities	Electrified USD/Month	Unelectrified USD/Month
10%	\$85.49	\$147.25
20%	\$51.79	\$10.59
35%	\$23.02	\$3.89
50%	\$15.33	\$2.50
75%	\$7.14	\$1.27
90%	\$5.18	\$0.30

The detailed conclusions of the survey results and energy expenditure analysis are presented in the electrification report. The survey instruments and questionnaires are in Annex A.

Summary of Energy Expenditure Results

Approximately 80 to 90 percent of electrified households surveyed reported a direct connection to the mini-grid service provider, while approximately 10 percent of electrified households were connected to a neighbouring household. A relatively small percentage of unelectrified households in the electrified (mini-grid) service areas rely on standalone solar solutions for their electricity needs. In sample areas outside the reach of mini-grid service providers, approximately 35 to 45 percent of households reported using standalone solar solutions for their electricity needs, in addition to rechargeable batteries (mainly for mobile phones) and AA batteries. In the southern zone 38 percent of unelectrified households reported using kerosene.

Table 25 and Table 26 summarize the monthly energy expenditure by percentage of respondents for residential, commercial and public facilities sampled in all three zones. The high-expenditure category corresponds to the top 20 percent of all residential and commercial consumers, while the medium-expenditure category corresponds to 20 to 50 percent of the residential and commercial consumer population. The low-expenditure category corresponds to the bottom 50 percent of residential and commercial consumers. Note the significant difference between electrified and unelectrified commercial and public facilities surveyed.

It is also worth noting that tariffs charged by mini-grid service providers vary significantly. The mini-grid service provider Fandriana in the central zone charges the lowest average tariff (USD 0.14 per kWh). Mini-grids in the northern zone reported the highest tariffs that are charged based on a pricing bundle for a fixed quantity of energy over a set duration – similar in nature to mobile phone data bundles. The bundled prices provide single-phase consumers with between 0.13 kWh for a single day and 18 kWh over a 30-day period at prices that vary between MGA 800 to 65,000. For the 30-day bundles, this equates to a tariff of approximately USD 0.83 per kWh. This in part likely explains why expenditure for electrified customers is higher in the northern zone than other zones.

Table 25. Monthly residential energy expenditure for northern, central and southern zones.

Residential	Electrified USD/Month	Unelectrified USD/Month	Electrified USD/Month	Unelectrified USD/Month	Electrified USD/Month	Unelectrified USD/Month
Zone:	Northern		Central		Southern	
10%	\$21.84	\$5.41	\$ 7.37	\$5.35	\$16.34	\$5.87
20%	\$14.67	\$3.53	\$ 4.74	\$3.98	\$9.76	\$3.80
35%	\$9.55	\$2.61	\$ 3.80	\$2.88	\$6.02	\$2.70
50%	\$7.25	\$2.10	\$ 3.46	\$2.15	\$4.83	\$1.82
75%	\$6.91	\$1.00	\$ 2.43	\$1.15	\$2.95	\$1.07
90%	\$5.52	\$0.72	\$ 1.25	\$0.70	\$1.97	\$0.38

Table 26. Monthly commercial energy expenditures for northern, central and southern zones

Commercial and Public Facilities	Electrified USD/Month	Unelectrified USD/Month	Electrified USD/Month	Unelectrified USD/Month	Electrified USD/Month	Unelectrified USD/Month
Zone:	Northern		Central		Southern	
10%	\$85.49	\$147.25	\$40.28	\$3.30	\$43.40	\$13.46
20%	\$51.79	\$10.59	\$19.73	\$2.65	\$27.62	\$6.91
35%	\$23.02	\$3.89	\$11.51	\$0.86	\$18.15	\$3.73
50%	\$15.33	\$2.50	\$8.38	\$0.53	\$10.11	\$2.77
75%	\$7.14	\$1.27	\$4.14	\$0.01	\$4.93	\$1.04
90%	\$5.18	\$0.30	\$2.49	\$0.01	\$2.58	\$0.24

Energy expenditure results, presented in Tables 25 and 26, were used to corroborate the energy consumption levels with which demand was evaluated for on-grid and off-grid projects within the electrification results described in this report. These results illustrate differences in consumption and expenditure patterns between the three regions and demonstrate a substantial latent demand for energy services for commercial and public facilities. The results provide a useful assessment of energy expenditure trends in Madagascar that can be combined with other sources of information from ADER, private operators or other donor-funded programmes to provide robust estimations of household, commercial and public institutions' demand and potential electricity consumption. However, due to the timeline between the completion of the energy expenditure surveys and the electricity analysis, the results of the surveys were not available to feed directly into the electrification model; nonetheless the two corroborate the energy consumption values chosen for residential commercial/public facility loads. Estimates of these are provided in the design assumptions section below.

Clean Cooking

This section of the report provides statistics on cooking for the surveyed households and small commercial and public facilities in each of the three surveyed zones in Madagascar. Specifically, it provides generalizable findings across all surveyed zones, and any specific inferences based on geospatial area or respondent type, to inform nation-wide geospatial analyses on cookstoves, fuels and cooking practices.

Summary: Cookstoves and Fuels

Table 27 shows the stoves observed in the study, noting if they were used by households only, institutions only, or both. Fuel types included fuelwood, charcoal, electricity, LPG, biogas and others (not defined). Surveys for households identified 12 types of cookstove in use, and surveys for institutions identified 10 types of cookstove in use. Two types of fuelwood stoves (three-stone and basic), the electric kettle, the electric oven and LPG cylinders were observed in both households and institutions.

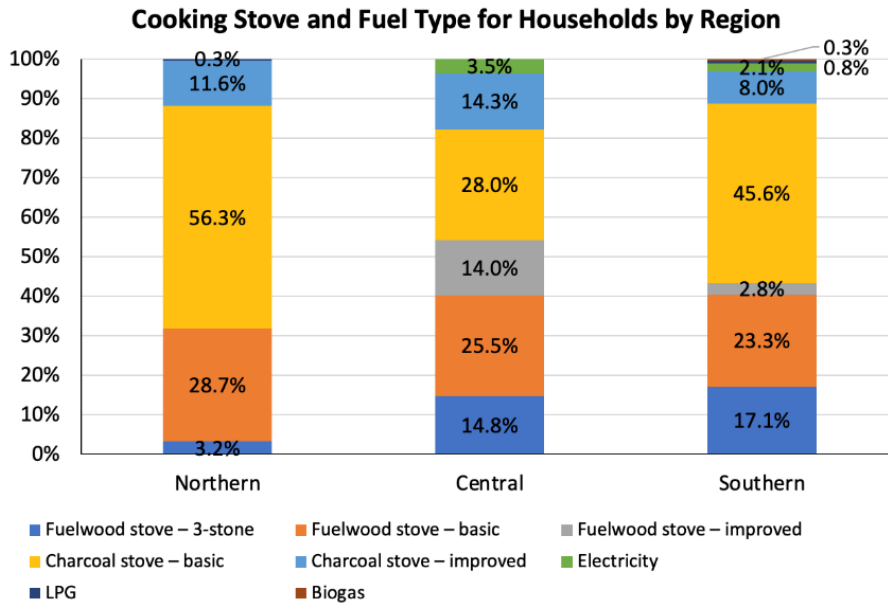
Table 27. Fuel and stove type used by households and institutions

Fuel and Stove type	MTF Tier	Household Use	Institution Use
Fuelwood stove – 3-stone	0	x	x
Fuelwood stove – basic	1	x	x
Fuelwood stove – improved	2	x	
Fuelwood stove – basic institutional	2		x
Fuelwood stove – improved institutional	3		x
Charcoal – basic	1	x	
Charcoal – improved	2	x	
Charcoal – basic institutional	2		x
Charcoal – improved institutional	3		x
Electric – rice cooker	5	x	
Electric – kettle	5	x	x
Electric – fryer	5	x	
Electric – oven	5	x	x
Electric – microwave	5	x	
LPG – cylinder	4	x	x
Biogas	4	x	
Other (not defined)	N/A		x
Total	N/A	12	10

Stove types in households vary by region, as shown in Figure 10 for the 1,163 stoves from 1,069 households that reported cooking. There is more use of charcoal in the northern region, with 67.9 percent of households using charcoal and 31.8 percent using fuelwood. Fuelwood and charcoal use are not equal but are more similar in the two other regions – 54.3 percent and 42.5

percent in the central region and 43.3 percent and 53.6 percent in the southern region for fuelwood and charcoal, respectively. Electricity use is minimal; it is not used in the northern region and is used by only 3.5 percent of households in the central region and 2.1 percent of households in the southern region. The use of LPG and other stove types is negligible.

Figure 10. Cookstove and fuel type for households by region



62 respondents for institutional cooking use 84 cookstoves (accounting for stove stacking). This number is not big enough to separate data by region (three regions) or stove type (10 stoves) because the number of combinations (30 combinations) is high relative to the observations. The data are thus not separated by region as presented in Figure 11. 23.8 percent of the respondents used fuelwood, 63.1 percent used charcoal, 4.8 percent used electricity and 8.3 percent used LPG or other (undefined) sources.

Figure 11. Cookstove and fuel type for institutions by region

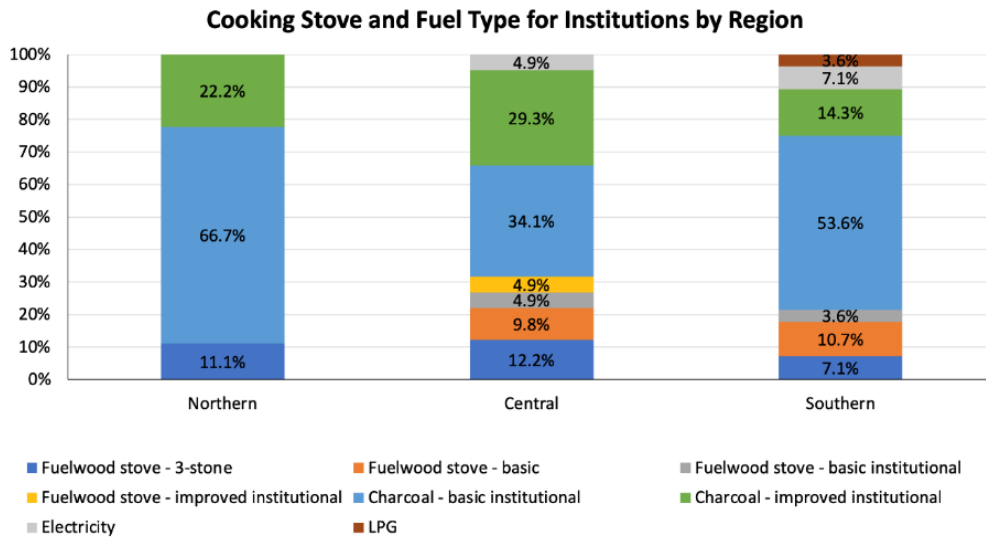
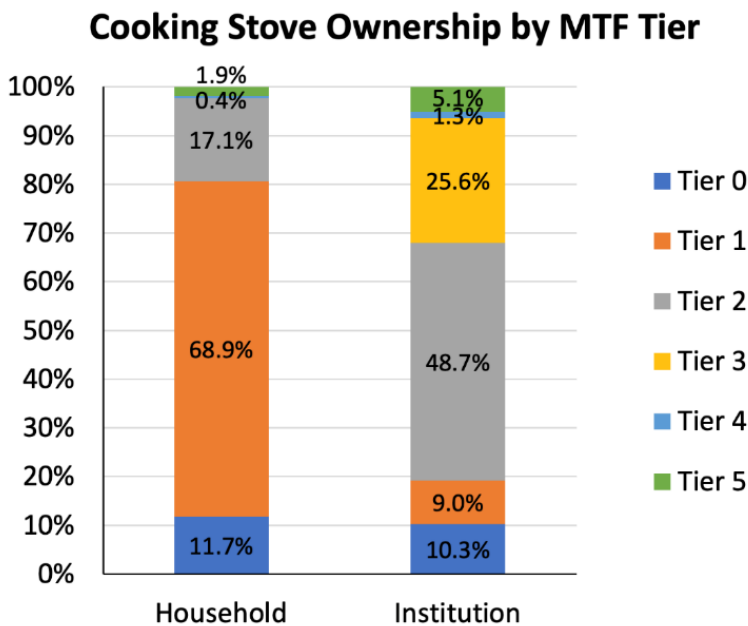


Figure 12 categorizes these household and institution stove ownership patterns by Multi-Tier Framework (MTF) tiers. Most respondents in each group own tier 3 stoves (charcoal stoves) and the second most common category is tier 0 (three-stone or basic fuelwood stove). Other tiers were uncommon.

Figure 12. Cookstove ownership by MTF tier



Cookstove Ownership and Use

Household respondents tended to have one stove; 90.9 percent of respondents reported using only one stove. Only 8.5 percent of households participate in cookstove stacking and use multiple stoves. A small number, 0.7 percent of households, used no stove, presumably because they visited nearby family for meals. Table 28 shows that owning more than two stoves was

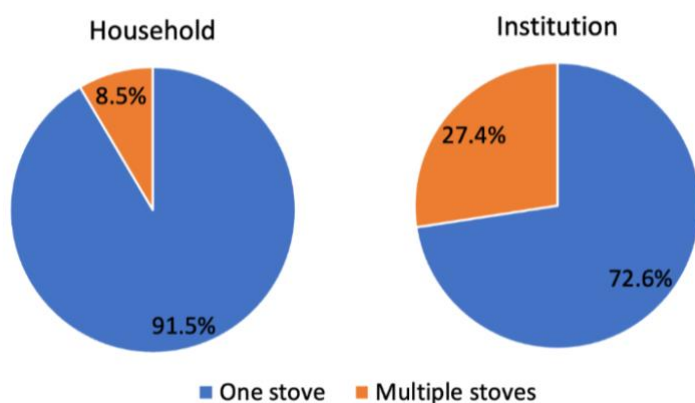
uncommon (0.5 percent of total respondents). Most institution respondents do not own a stove, as shown in Table 29, leaving only 62 of the 331 institutions surveyed able to provide any data on stove ownership, cooking practices and fuel use. Of note is that stove stacking was far more common among institutions than households, with over three times the percentage of respondents indicating they participated in stove stacking. Figure 13 provides a graphical summary of this trend.

Table 28. Household stove ownership counts with percentages shown of total respondents

Stove count	Respondent Count	Percentage of Respondents (%)
0 stove	7	0.7%
1 stove	978	90.9%
2 stoves	86	8.0%
3 stoves	4	0.4%
4 stoves	1	0.1%
Total	1076	100.0%

Table 29. Institution stove ownership counts with percentages shown of total respondents

Stove count	Respondent Count	Percentage of Respondents (%)
0 stove	269	81.3%
1 stove	45	13.6%
2 stoves	12	3.6%
3 stoves	5	1.5%
4 stoves	0	0.0%
Total	331	100.0%

Figure 13. Stove stacking occurrences for household and institutions

The analysis presented above does not include respondents who do not own stoves. This leaves 1,069 households and 62 institutions who own stoves and who are the focus of the remaining parts of the analysis.

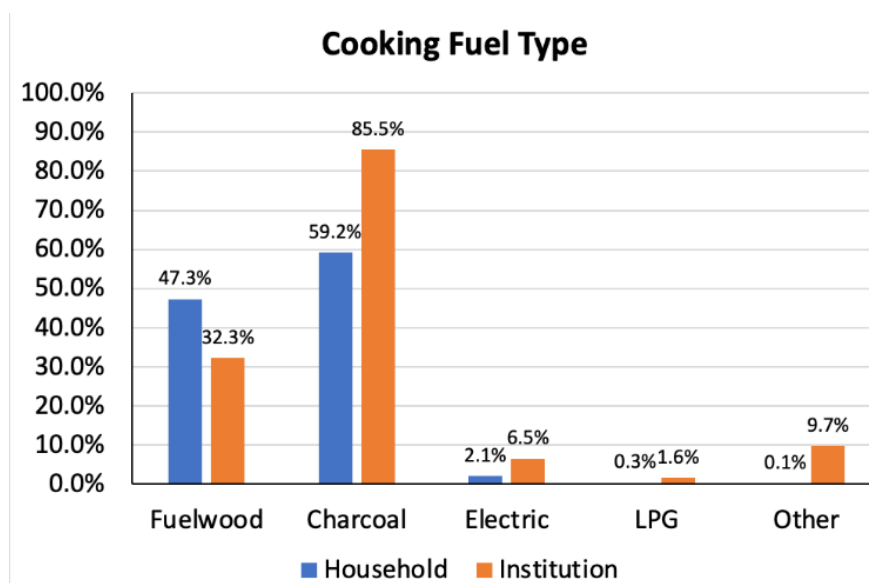
Stove ownership for households and institution respondents is given in Table 28 and Table 29, respectively. Totals in the tables sum to greater than the total number of household respondents due to stove stacking. Figure 14 provides a summary of ownership patterns. Solid fuel stoves are clearly more prevalent than any other fuel type, with charcoal being the most common stove type observed in both households and institutions.

Table 28. Household stove ownership with percentages shown of total respondents

Fuel and Cookstove Type	Respondent Count	Percentage of Respondents (%)
Fuelwood stove – 3-stone	135	12.5%
Fuelwood stove – basic	303	28.2%
Fuelwood stove – improved	67	6.2%
Charcoal stove – basic	500	46.5%
Charcoal stove – improved	132	12.3%
Electric – rice cooker	15	1.4%
Electric – kettle	4	0.4%
Electric – fryer	1	0.1%
Electric – oven	1	0.1%
Electric – microwave	1	0.1%
LPG – cylinder	3	0.3%
Biogas	1	0.1%
Total	1163	N/A

Table 29. Institution stove ownership with percentages shown of total respondents

Fuel and Cookstove Type	Respondent Count	Percentage of Respondents (%)
Fuelwood stove – 3-stone	8	12.9%
Fuelwood stove – basic	7	11.3%
Fuelwood stove – basic institutional	3	4.8%
Fuelwood stove – improved institutional	2	3.2%
Charcoal – basic institutional	34	54.8%
Charcoal – improved institutional	19	30.6%
Electric – oven	2	3.2%
Electric – kettle	2	3.2%
LPG – cylinder	1	1.6%
Other	6	9.7%
Total	84	N/A

Figure 14. Cooking fuel types for households and institutions

Household stove stacking behaviours are given in Table 30 for each stove ownership group. A total of 79.1 percent of households participating in stove stacking use a fuelwood stove and a charcoal stove. Electricity and a biomass stove are used by 18.7 percent of respondents, with all but one of these respondents using a charcoal stove, suggesting that minimal or negligible stacking occurs with a fuelwood stove and an electric stove. For institutional respondents, a smaller number – 64.7 percent of respondents – used both fuelwood and charcoal, with 11.8 percent using charcoal and electric stoves, and 23.5 percent showing other stove stacking behaviours. These figures are given in Figure 14.

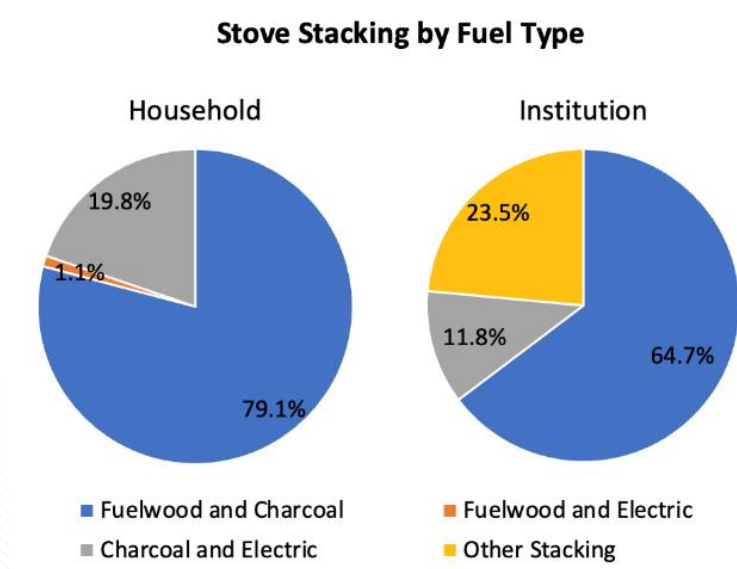
Table 30. Household stove stacking behaviours shown as stove ownership groups with percentages shown of respondents participating in stove stacking

Fuel and Cookstove Type	Respondent Count	Percentage of Respondents (%)
Fuelwood stove – 3-stone & fuelwood stove – basic	2	2.2%
Fuelwood stove – 3-stone & fuelwood stove – basic & charcoal stove – basic	1	1.1%
Fuelwood stove – 3-stone & charcoal stove – basic	11	12.1%
Fuelwood stove – 3-stone & charcoal stove – improved	2	2.2%
Fuelwood stove – basic & charcoal stove – basic	19	20.9%
Fuelwood stove – basic & charcoal stove – improved	3	3.3%
Fuelwood stove – basic & electric – rice cooker	1	1.1%
Fuelwood stove – basic & fuelwood stove – improved	4	4.4%
Fuelwood stove – basic & LPG – cylinder	2	2.2%
Fuelwood stove – improved & charcoal stove – basic	3	3.3%
Fuelwood stove – improved & charcoal stove – improved	2	2.2%
Charcoal stove – basic & charcoal stove – improved	25	27.5%
Charcoal stove – basic & electric – kettle	1	1.1%
Charcoal stove – basic & electric – kettle & electric – fryer & electric – rice cooker	1	1.1%
Charcoal stove – basic & electric – kettle & electric – rice cooker	1	1.1%
Charcoal stove – basic & electric – rice cooker	5	5.5%
Charcoal stove – basic & electric – rice cooker & electric – microwave	1	1.1%
Charcoal stove – basic & electric – rice cooker & LPG – cylinder	1	1.1%
Charcoal stove – improved & electric – kettle	1	1.1%
Charcoal stove – improved & electric – rice cooker	5	5.5%
Total	91	100%

Table 31. Institution stove stacking behaviours shown as stove ownership groups with percentages shown of respondents participating in stove stacking

Fuel and Cookstove Type	Respondent Count	Percentage of Respondents (%)
Fuelwood stove - 3-stone & charcoal - basic institutional	3	17.6%
Fuelwood stove - 3-stone & charcoal - improved institutional	2	11.8%
Fuelwood stove - 3-stone & fuelwood stove - basic & charcoal - basic institutional	1	5.9%
Fuelwood stove - basic & charcoal - basic institutional	1	5.9%
Fuelwood stove - basic & charcoal - basic institutional & other	1	5.9%
Fuelwood stove - basic institutional & charcoal - improved institutional	1	5.9%
Charcoal - basic institutional & charcoal - improved institutional	3	17.6%
Charcoal - basic institutional & charcoal - improved institutional & electric - kettle	1	5.9%
Charcoal - basic institutional & charcoal - improved institutional & other	1	5.9%
Charcoal - basic institutional & electric - kettle & electric – oven	1	5.9%
Charcoal - basic institutional & LPG - cylinder	1	5.9%
Charcoal - improved institutional & other	1	5.9%
Total	17	100.0%

Figure 14. Stove stacking by fuel type for households and institutions.



Respondents with multiple stoves were also asked which stove they used most often. Data in Table 32 show these preferences for household respondents. Data records for institutional respondents showed preferences for cookstoves they didn't use at the institution, and perhaps

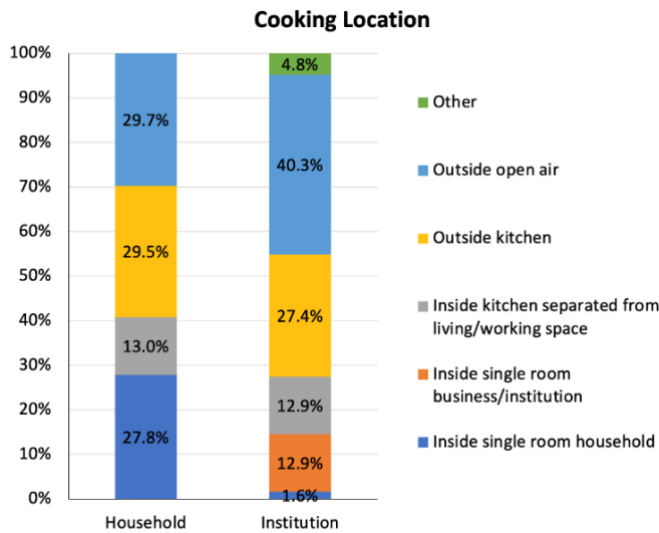
the question was misinterpreted to mean: “Which stove do you prefer [the one at home or the one at the institution]?”.

Table 32. Household stove preferences for respondents who own multiple stoves

Ownership				Preference			
Stove A	Stove B	Stove C	Stove D	Stove A	Stove B	Stove C	Stove D
Firewood stove – 3-stone	Firewood stove – basic			1	1	0	0
Firewood stove – 3-stone	Firewood stove – basic	Charcoal stove – basic		0	1	0	0
Firewood stove – 3-stone	Charcoal stove – basic			6	5	0	0
Firewood stove – 3-stone	Charcoal stove – improved			0	2	0	0
Firewood stove – basic	Charcoal stove – basic			11	8	0	0
Firewood stove – basic	Charcoal stove – improved			1	2	0	0
Firewood stove – basic	Electric – rice cooker			1	0	0	0
Firewood stove – basic	Firewood stove – improved			1	3	0	0
Firewood stove – improved	Charcoal stove – basic			3	0	0	0
Firewood stove – improved	Charcoal stove – improved			2	0	0	0
Charcoal stove – basic	Charcoal stove – improved			8	17	0	0
Charcoal stove – basic	Electric – kettle			1	0	0	0
Charcoal stove – basic	Electric – kettle	Electric – fryer	Electric – rice cooker	1	0	0	0
Charcoal stove – basic	Electric – kettle	Electric – rice cooker		1	0	0	0
Charcoal stove – basic	Electric – rice cooker			4	1	0	0
Charcoal stove – basic	Electric – rice cooker	Electric – microwave		1	0	0	0
Charcoal stove – basic	Electric – rice cooker	LPG – cylinder		1	0	0	0
Charcoal stove – basic	LPG – cylinder			1	1	0	0
Charcoal stove – improved	Electric – kettle			1	0	0	0
Charcoal stove – improved	Electric – rice cooker			5	0	0	0

Cooking location was predominantly outside, either in the open air or in an outside kitchen. Figure 15 summarizes cooking locations for respondents for both households and institutions. Outdoor cooking commonly has more airflow and ventilation, thereby reducing exposure to emissions.

Figure 15. Cooking location for households and institutions

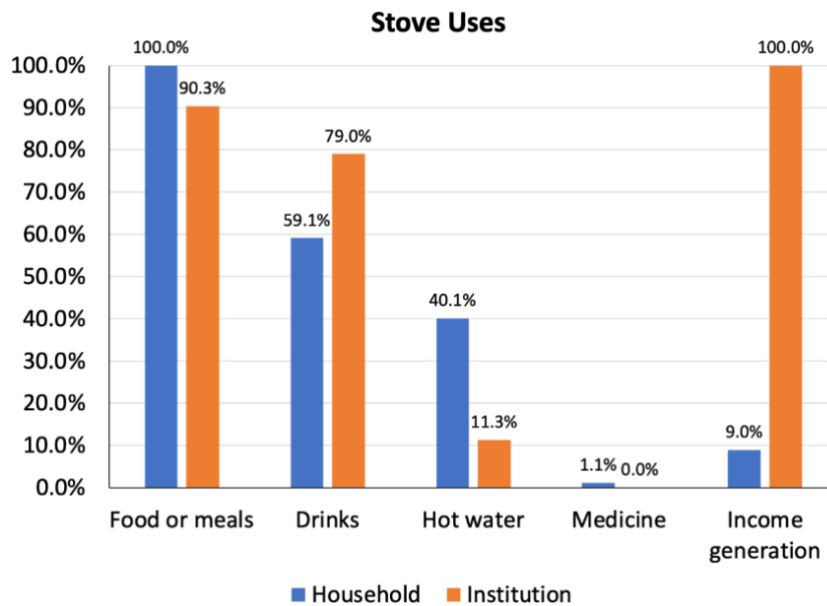


Uses of Cookstoves

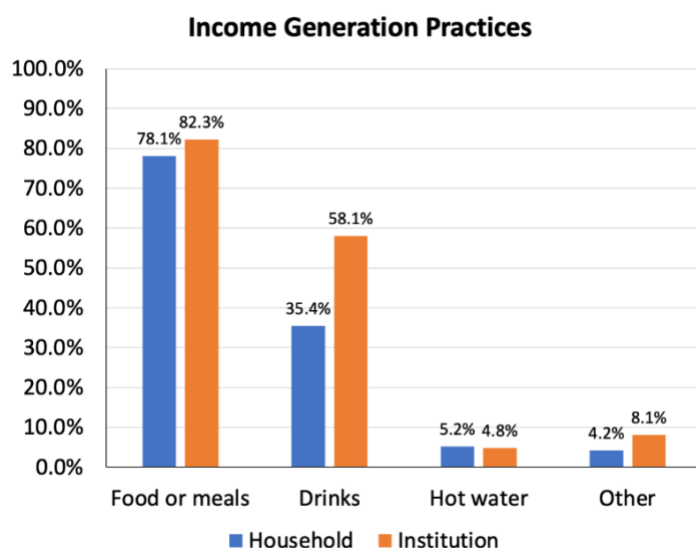
Cookstoves are used for five main reasons – preparing food or meals, preparing drinks, heating water (for washing or bathing), medicine and income generation. Medicine was the only response given in the “other” category of the question: “What else do you use the cookstove for?” Figure 16 shows the responses by percentage of respondents. For households, it is not

surprising that all households prepare food or meals on the cookstove, though a smaller number of respondents than expected indicated they used their cookstove to heat water, which could suggest they obtain hot water from a neighbour or use an appliance that isn't considered a cookstove (such as solar hot water heating, or that they simply don't use hot water for any other purpose than for preparing food or drinks and such uses are already captured in the question). All institutions reported receiving some form of income from the use of their stoves for meals, drinks, or hot water. This is higher than expected when noting that not all institutions are businesses, which could mean that the public institutions somehow receive remuneration for use of the stoves, or, that the question was misinterpreted in some way.

Figure 16. Stove uses for households and institutions



96 households and 62 institutions reported using stoves for income generation practices. The main use was selling meals, with selling drinks as a secondary use. Figure 17 shows that heating water and other uses were occasionally pursued for income generation, but these occurrences were small relative to meal and drink preparation.

Figure 17. Income generation practices for households and institutions

Frequency of meal preparation was surveyed for breakfast, lunch, dinner and snacks. Table 33 shows that a noticeable percentage of households (8.2 percent) skipped breakfast whereas only one in 20 households did not make lunch. Nearly all households made dinner. Snacks were prepared by a minority of households and at irregular frequencies. Table 34 shows that at institutions, breakfast and lunch were more commonly made for income generation as opposed to dinner, which also aligns well with the household data suggesting that nearly all respondents cook dinner (even if everyone in the household isn't present for dinner and procures dinner from an institution or another household). Approximately one-half of institutions prepared snacks for income generation.

Table 33. Frequency of meal preparation for households

Frequency of Meal Preparation	Breakfast	Lunch	Dinner	Snacks
Never	8.2%	0.8%	0.1%	70.8%
Daily	88.5%	95.3%	99.8%	4.5%
Every 2 days	2.6%	3.5%	0.0%	2.3%
Every 3 days	0.7%	0.3%	0.0%	3.4%
Every 4 days	0.0%	0.0%	0.0%	1.6%
Every 5 days	0.0%	0.0%	0.0%	1.9%
Every 6 days	0.0%	0.1%	0.0%	2.0%
Every 7 days	0.0%	0.0%	0.1%	6.4%
Less than once per week	0.0%	0.0%	0.0%	7.2%

Table 34. Frequency of meal preparation for institutions

Frequency of Meal Preparation	Breakfast	Lunch	Dinner	Snacks
Never	15.8%	8.8%	31.6%	36.8%
Daily	82.5%	91.2%	68.4%	49.1%
Every 2 days	0.0%	0.0%	0.0%	3.5%
Every 3 days	0.0%	0.0%	0.0%	3.5%
Every 4 days	0.0%	0.0%	0.0%	0.0%
Every 5 days	0.0%	0.0%	0.0%	0.0%
Every 6 days	0.0%	0.0%	0.0%	0.0%
Every 7 days	0.0%	0.0%	0.0%	3.5%
Less than once per week	1.8%	0.0%	0.0%	3.5%

Cookstove Procurement

Figure 18 and Figure 19 show that most cookstoves among household respondents were purchased outright, and while Figure 18 suggests some evidence of payment plans, the total number of cookstoves in those categories is low; only 1.3 percent of all stoves were purchased on a payment plan. Respondents indicating “purchased outright” for a three-stone fire most likely fall into the category “made it myself”; it is possible translation or interpretation errors caused this trend in the data, or, that a few respondents did pay someone to make their three-stone fire.

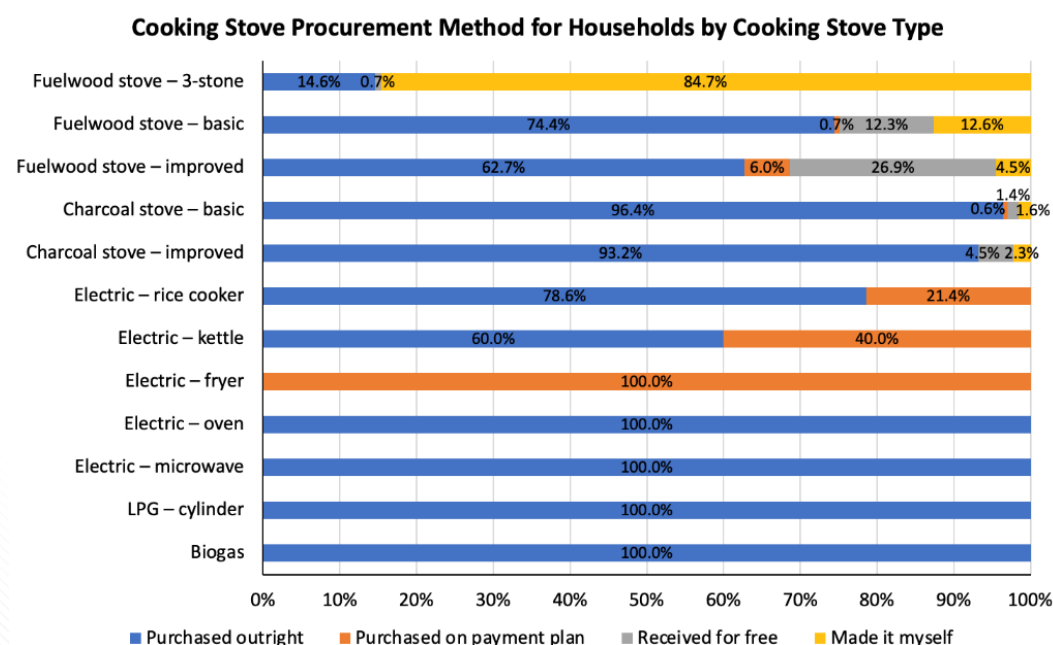
Figure 18. Cookstove procurement method for households by cookstove type

Figure 19. Cookstove procurement method for households by all cookstoves

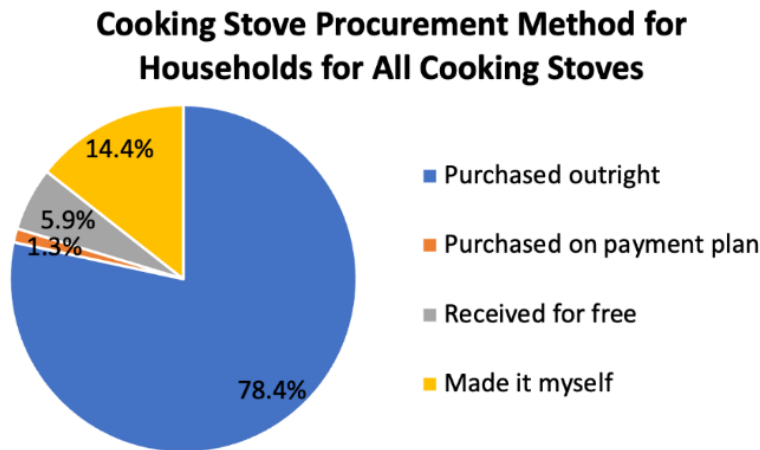


Figure 20 and Figure 21 show that most cookstoves among institution respondents were purchased outright, some were made by the store owners or workers and a small number were received for free. Payment plans were not used by any of the respondents. This could mean that payment plans were not available or that respondents simply did not need them, and the latter possibility also matches findings from a later section in this report that only a few institutions indicated that stove price was a barrier to improved stove access.

Figure 20. Cookstove procurement method for institutions by cookstove type

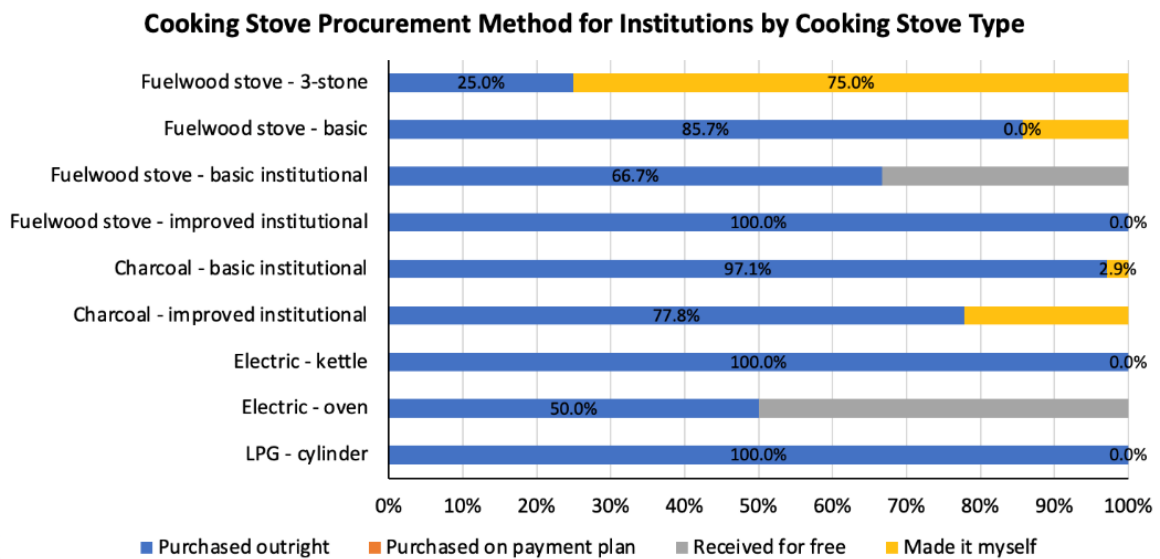


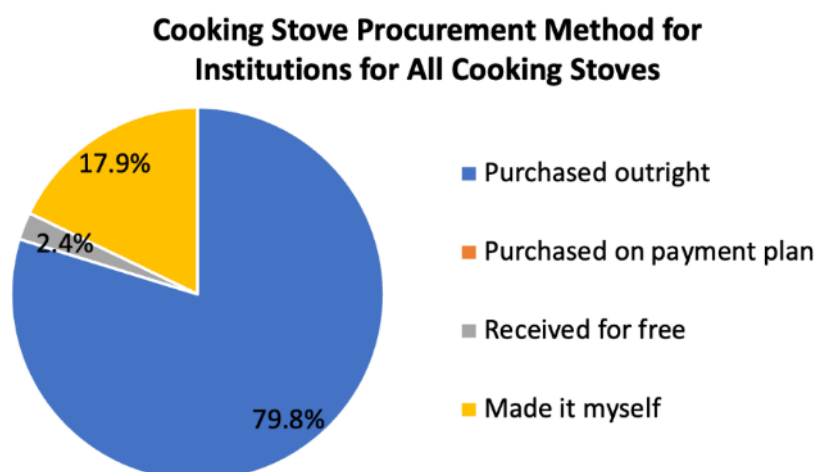
Figure 21. Cookstove procurement method for institutions by all cookstoves

Table 35 and Table 36 show the prices of stove procurement for households and institutions, respectively. Charcoal stoves, for both households and institutions, tend to be more expensive in the northern region than in the central and southern regions. The institutional LPG cookstove is most likely larger than the LPG cookstove procured by households. There is insufficient contextual information to address seemingly anomalies such as: (a) Why did respondents mention paying for a three-stone fire, and households indicate it was more expensive than a basic fuelwood stove? (b) Why is it that certain stoves and/or regions have a lower reported price for an “improved” stove in relation to its simpler “basic” counterpart? These types of questions require more detailed information that was not possible to gather in the time allocated for the project.

Table 35. Average prices of cookstoves paid by households, organized by region and the whole country

Fuel and Cookstoves Type	Northern	Central	Southern	Country
Fuelwood stove – 3-stone	\$1.38	-	\$1.28	\$1.29
Fuelwood stove – basic	\$1.34	\$1.45	\$0.86	\$1.20
Fuelwood stove – improved	-	\$1.37	\$3.22	\$1.73
Charcoal stove – basic	\$4.37	\$2.45	\$2.51	\$3.29
Charcoal stove – improved	\$4.43	\$5.89	\$3.36	\$4.77
Electric – rice cooker	-	\$21.15	\$51.79	\$27.28
LPG – cylinder	-	-	\$12.66	\$12.66

Table 36. Average prices of cookstoves paid by institutions, organized by region and the whole country

Fuel and Cookstove Type	Northern	Central	Southern	Country
Fuelwood stove - 3-stone	-	-	\$0.35	\$0.35
Fuelwood stove - basic	-	\$0.92	\$2.42	\$1.92
Fuelwood stove - basic institutional	-	\$6.91	\$6.44	\$6.68
Fuelwood stove - improved institutional	-	\$2.07	-	\$2.07
Charcoal - basic institutional	\$9.13	\$5.15	\$6.14	\$6.30
Charcoal - improved institutional	\$11.97	\$4.54	\$7.06	\$6.41
Electric - kettle	-	\$8.06	-	\$8.06
LPG - cylinder	-	-	\$63.76	\$63.76

Training for the use of cookstoves is not common. For household respondents, 92.0 percent received no training, 7.9 percent received some training and 0.1 percent didn't know if they had received training. This trend was largely the result of the significant proportion of respondents with a basic cookstove that they knew how to operate by watching family members. Figure 22 shows the breakdown of training by cookstove types for households. 82.1 percent of respondents from institutions received no training, 16.7 percent received some training, and 1.3 percent didn't know if they had received training. Figure 23 shows the breakdown of training by cookstove types for institutions.

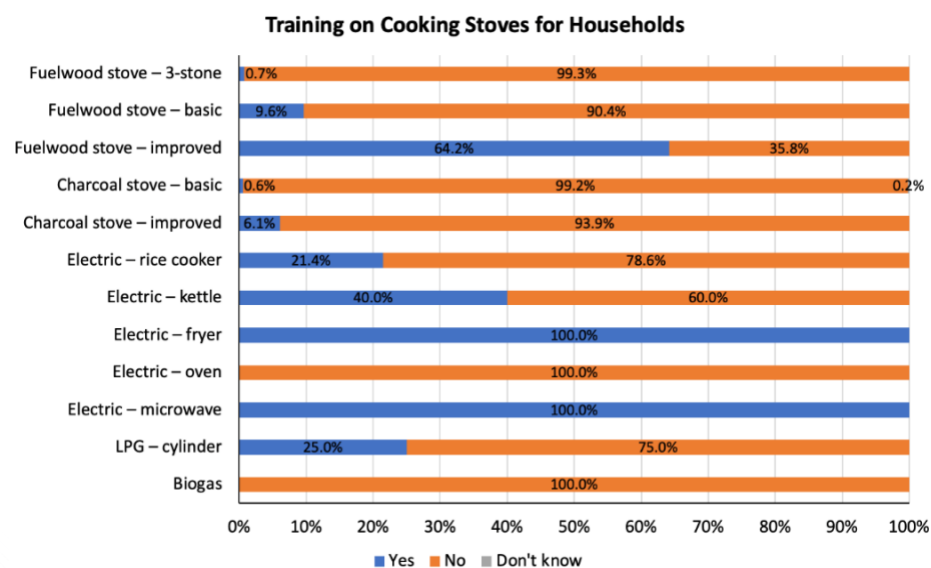
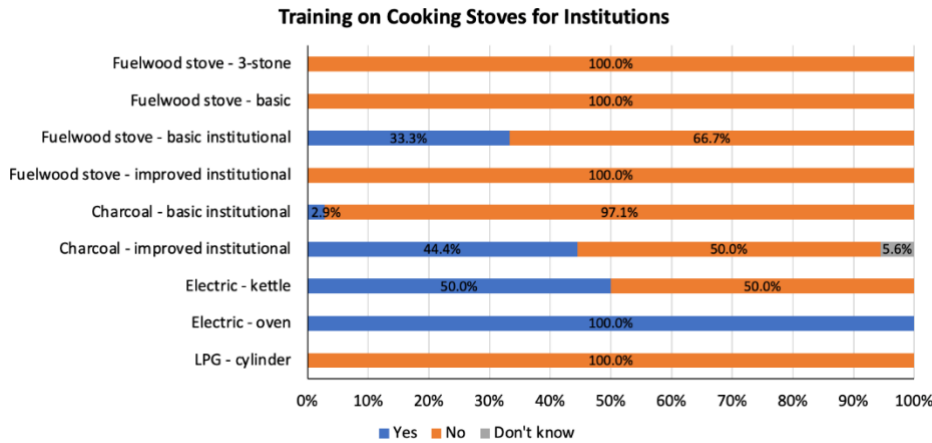
Figure 22. Training on cookstoves for households

Figure 23. Training on cookstoves for institutions



Fuel Collection and Purchasing Practices

As for fuel collection and purchasing practices, 73.5 percent of household respondents purchase fuel and 21.7 percent freely collect fuel, with a small number (0.8 percent) producing fuel and 4.0 percent having another method of obtaining fuel. Figure 24 shows these figures by fuel type and Table 37 provides more details on collection and purchasing locations.

Figure 24. Fuel collection and purchasing practices for households

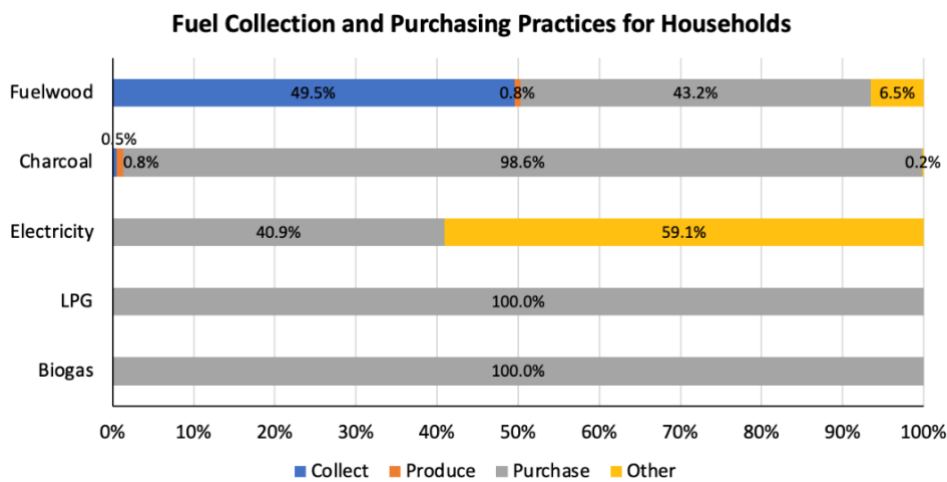


Table 37. Fuel collection and purchasing practices for households, detailed

Collection	Fuelwood	Charcoal	Electricity	LPG / Other
Bush	100.0%	0.0%	0.0%	0.0%
Farm	100.0%	0.0%	0.0%	0.0%
Farm and bush	100.0%	0.0%	0.0%	0.0%
Forest	98.6%	1.4%	0.0%	0.0%
Mountain	100.0%	0.0%	0.0%	0.0%
Self-produce	44.4%	55.6%	0.0%	0.0%
Market	38.2%	59.8%	0.0%	2.0%
Mobile supplier	18.7%	79.7%	1.4%	0.2%
Neighbour	85.7%	14.3%	0.0%	0.0%
Other	70.2%	2.1%	27.7%	0.0%

The fuel prices in Table 38 were sourced from the central and northern regions and are considered representative of the country. Two types of charcoal were locally described as coming from “light wood” and “quality wood”, or denser wood. Prices in USD per kg are 0.027 for fuelwood and 0.119 for charcoal (averaged across all charcoal sources). Respondents did not describe what type of charcoal they used so all charcoal is considered equivalent for the purposes of this analysis. One bundle of light wood weighs 0.8 kg and one bundle of quality wood weighs 1.8 kg.

Table 38. Fuel prices observed in the market

Fuel	Size (description)	Size (kg)	Price (MGA)	Price (MG/kg)	Price (USD/kg)
Fuelwood	1 bundle (kitay)	4	500	125	0.027
Charcoal (quality wood)	1 bundle	1.8	1000	556	0.121
Charcoal (quality wood)	4 bundles	7.2	4500	625	0.136
Charcoal (quality wood)	13 bundles	23.4	15000	641	0.139
Charcoal (light wood)	1 bundle	0.8	500	625	0.136
Charcoal (light wood)	24 bundles	19	8000	421	0.092
Charcoal (light wood)	30 bundles	24	10000	417	0.091

All fuel types were available for most households and most institutions, as shown in Figures 25 and 26, respectively. There were longer periods of time when fuelwood and charcoal were not available, while other fuels were always available or were unavailable for minimal periods of time (1 of 21 observations for electricity for households). In terms of fuelwood and charcoal availability, as seen in Figures 27 and 28, there is less of both fuel types in the northern region, and the central region seems to have slightly better availability than the southern region. A similar analysis for institutions couldn't be completed by region due to the limited number of respondents.

Figure 25. Fuel availability reported by households by fuel type

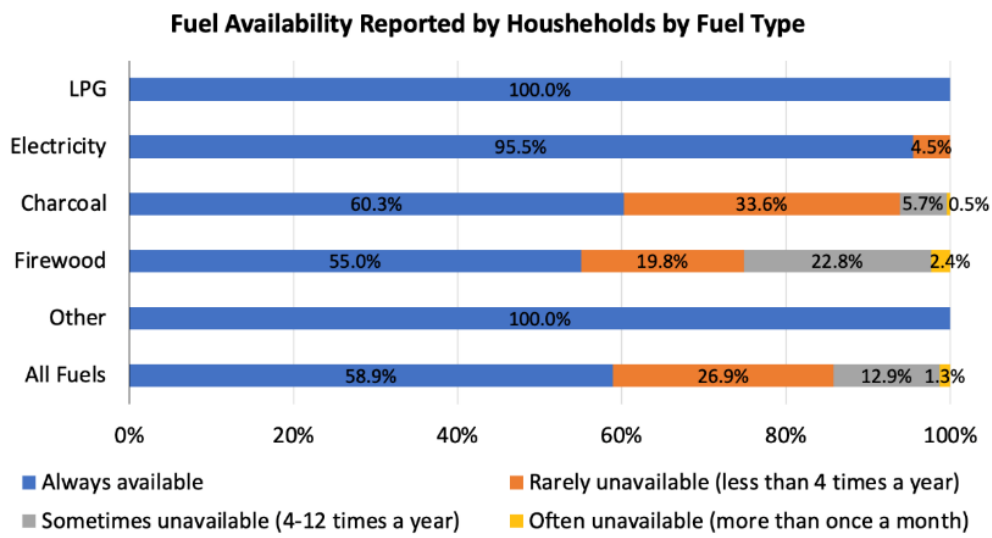


Figure 26. Fuel availability reported by institutions by fuel type

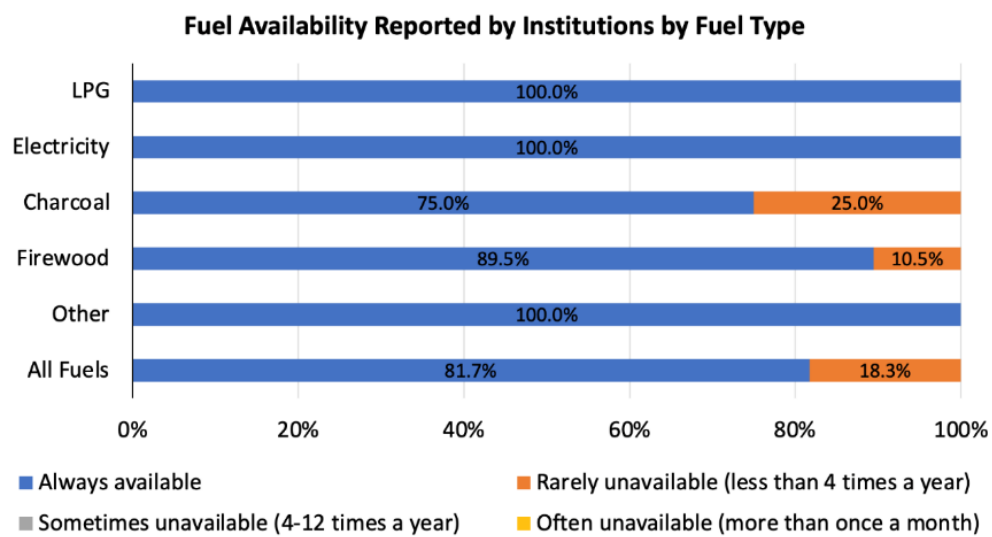
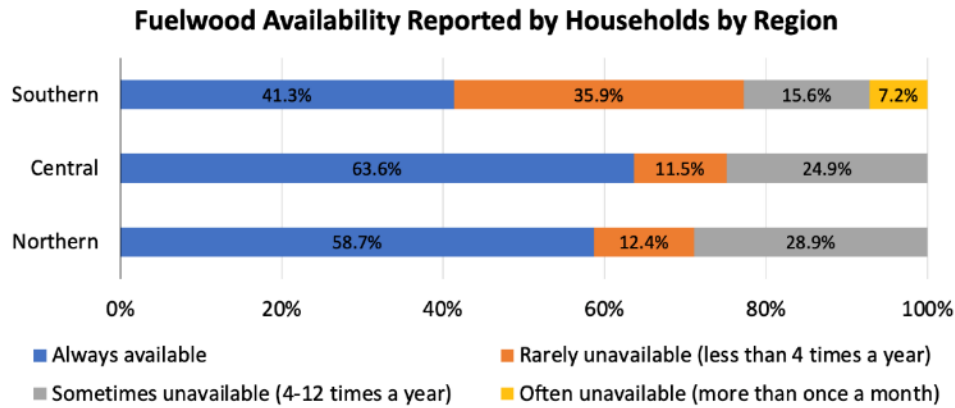
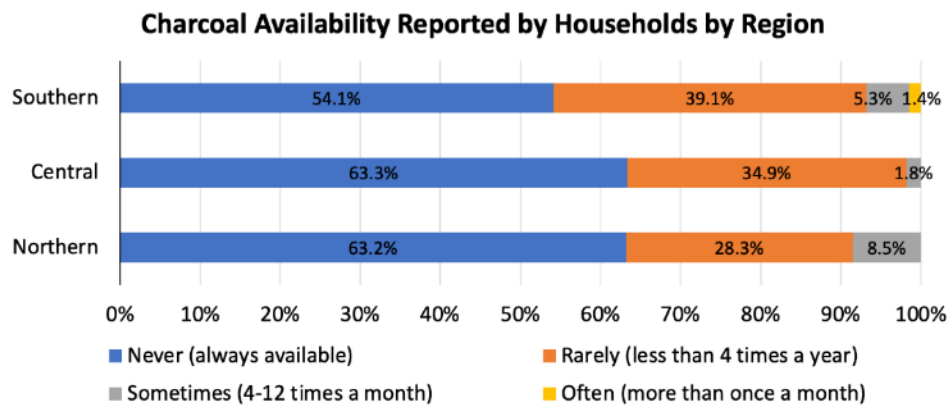


Figure 27. Fuelwood availability reported by households by region**Figure 28.** Charcoal availability reported by households by region

Fuel Use

Table 39 shows fuel use in households with the average and standard deviation of respondent reported information for fuelwood, charcoal and LPG stoves. Electricity users were not able to say how much electricity they had used for cooking in the past week, and hence, that information is not reported below. Similarly, the one biogas respondent indicated they had purchased biogas at the market, which suggests some confusion, and hence those data on cost are also omitted. Surveys of charcoal users did not differentiate by type of charcoal, and therefore we assume one “bundle” to be 1.3 kg, which is the average of light wood (0.8 kg / bundle) and quality wood (1.8 kg / bundle). Values reported by respondents had a wide range, hence the large standard deviation relative to the average value. Notably households using a basic fuelwood stove reported using it slightly more than the three-stone fire; this could be because of a number of factors such as smaller family size, the families had more uses for that cookstove (potentially due to higher income), the basic stove designs were not as efficient as perceived, or other factors. These values were used to create a single estimated amount of primary energy use for households, regardless of stove type.

Table 39. Fuel use per capita for households for an average week

Fuel and Cookstove Type	Average (kg/wk-p)	Std Dev (kg/wk-p)
Fuelwood stove – 3-stone	24.97	19.51
Fuelwood stove – basic	27.44	24.29
Fuelwood stove – improved	20.38	18.37
Charcoal stove – basic	0.57	2.29
Charcoal stove – improved	0.26	0.49
LPG – cylinder	2.71	4.26

Table 40 shows fuel use in institutions. Again, standard deviations are high relative to the mean because institutions may differ by volume and use – they may function as an eatery, a school, a place of worship, etc. There are insufficient data to disaggregate these institutions by type and then expand to the rest of Madagascar, thus, the average values are shown as representative of institutions generally. These values were used to create a single estimated amount of primary energy use for institutions, regardless of stove type.

Table 40. Fuel use for an average week for institutions

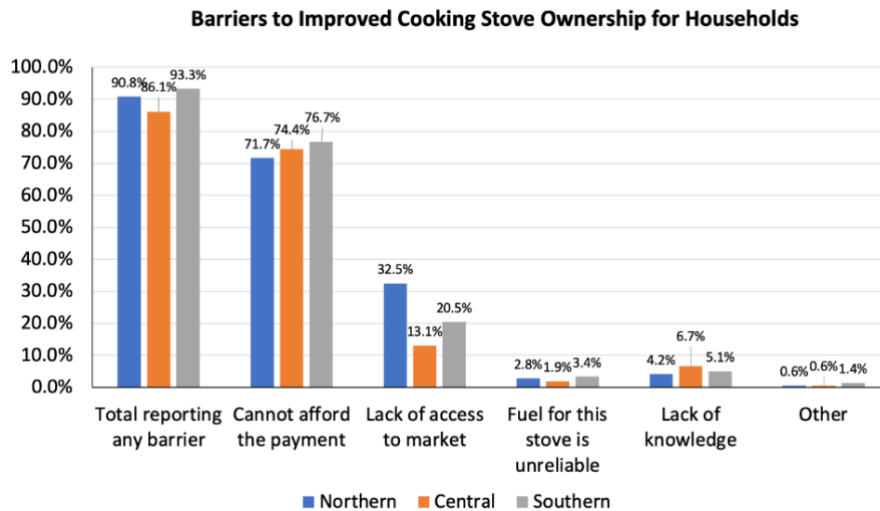
Fuel and Cookstove Type	Average (kg/wk)	Std Dev (kg/wk)
Fuelwood stove – 3-stone	121.00	124.04
Fuelwood stove – basic	177.14	152.87
Fuelwood stove – basic institutional	25.33	14.05
Fuelwood stove – improved institutional	57.00	77.78
Charcoal stove – basic institutional	3.68	3.06
Charcoal stove – improved institutional	4.66	8.00
Electricity (kWh)	4.50	3.00
LPG – cylinder	1.00	N/A

Barriers to Access

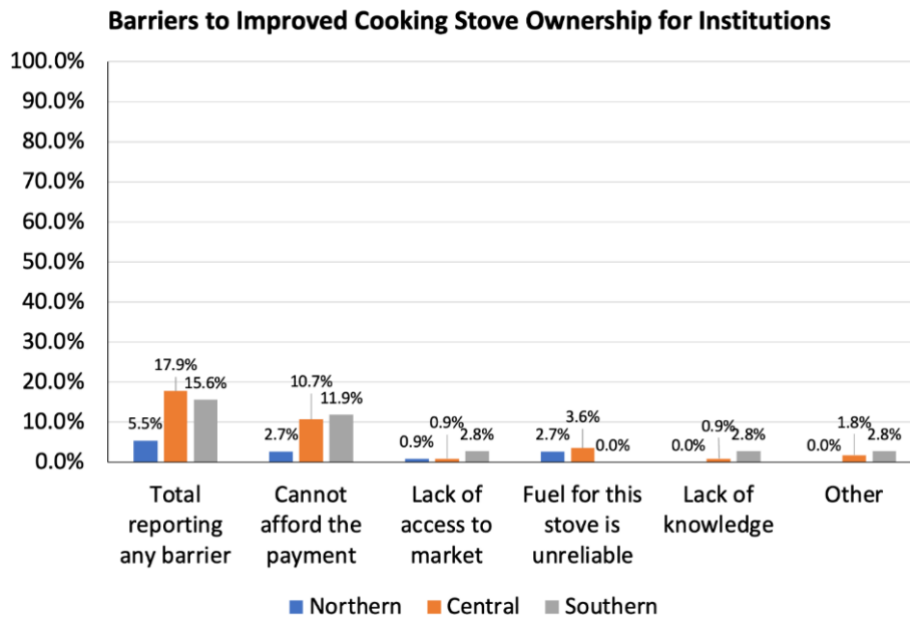
Barriers to households owning an improved cookstove are shown in Figure 29. Approximately nine in ten households said that some barrier existed to them owning an improved cookstove. Inability to afford the payment was the main reason given by three out of four households, regardless of the region surveyed. Notable regional differences in answers were found for respondents indicating a Lack of access to the market as a reason for not owning an improved cookstove; this was said to be a barrier by 32.5 percent of households in the northern region, 20.5 percent in the southern region and 13.1 percent in the central region. Very few respondents indicated fuel was unreliable or not available, which contrasts with the high-level attention of deforestation and presumed affects to rural households, and while the exact reasoning for this difference is unknown, it could be that the site assessment locations have greater availability of

fuelwood relative to other locations of the country. The “other” reasons for not owning improved cookstoves included a small number of respondents who indicated the stoves used too much energy, they weren’t user friendly, they saw them as a fire hazard, or electricity was not available 24 hours per day.

Figure 29. Barriers to improved cookstove ownership for households by region surveyed



Barriers to institutions owning an improved cookstove are shown in Figure 30. Far fewer institutions than households reported having a barrier to improved cookstove ownership. Again, inability to afford payments was the most frequent response of any barrier listed regardless of region surveyed. It is notable that the northern region had far fewer responses for all barriers, suggesting the types of respondents, market conditions, institution revenue vs. stove cost, or other factors may be making it easier for institutions in the northern region to procure the stoves they desire. The “other” respondent group had similar reasons to households.

Figure 30. Barriers to improved cookstove ownership for institutions by region surveyed

Gender and Youth Considerations

Women are predominantly responsible for obtaining fuels, as shown in Figure 31. Women collect fuels in a total of 73 percent of households surveyed, with 64 percent of households indicating women were solely responsible for obtaining fuel. This figure decreases when it comes to the free collection of fuel from the forest, bush and mountainside, with men more likely to be the sole person responsible for collecting fuel. Women are again more commonly in charge of fuel production (charcoal for self-use) and purchasing (from a market). The other category included scrap or leftover fuels obtained from locations such as a sawmill. The same information can also be categorized by fuel type, as shown in Figure 32, noting that the data are now aggregated across free collection, production, purchasing and other. Notably, women are primarily responsible for obtaining solid fuels but have less authority in obtaining cleaner fuels such as electricity, LPG and biogas.

Figure 31. Gender of person obtaining fuel for households by fuel procurement method

Gender of Person Obtaining Fuels for Households by Fuel Procurement Method

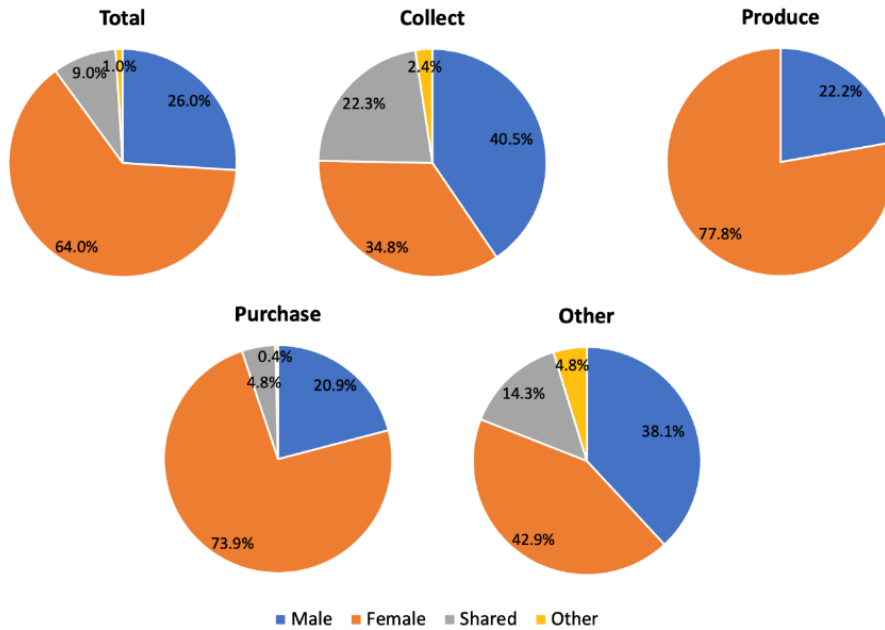
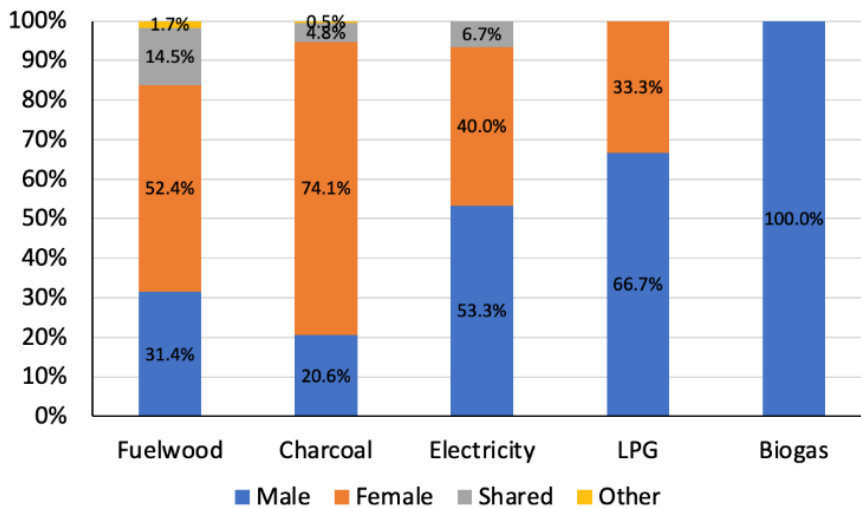


Figure 32. Gender of person obtaining fuel for households by fuel type

Gender of Person Obtaining Fuel for Households by Fuel Type



Similar analyses are made for institutions as shown in Figure 33 and Figure 34. Women have a more common role in fuel procurement for institutions than for households, largely driven by the high number of charcoal purchases made by women. Women are predominantly or solely responsible for procuring fuel across all fuel types. The small number of observations for free fuel collection (three observations) and other fuel procurement methods (two observations) are insufficient to draw any general conclusions from.

Figure 33. Gender of person obtaining fuel for institutions by procurement method

Gender of Person Obtaining Fuels for Institutions by Fuel Procurement Method

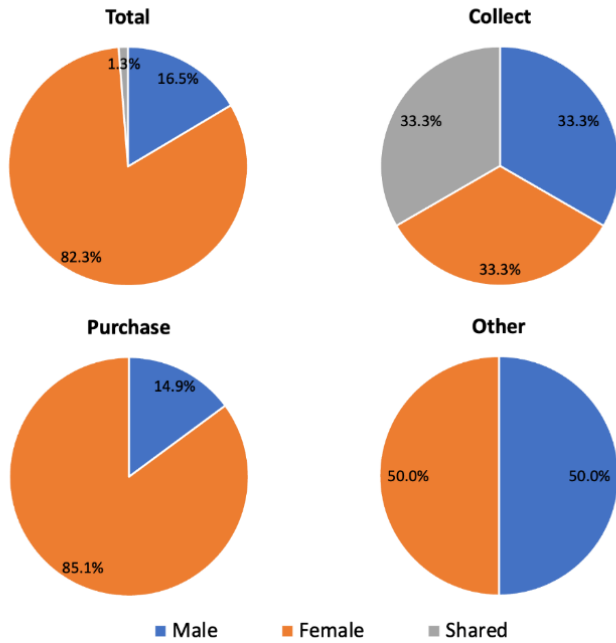
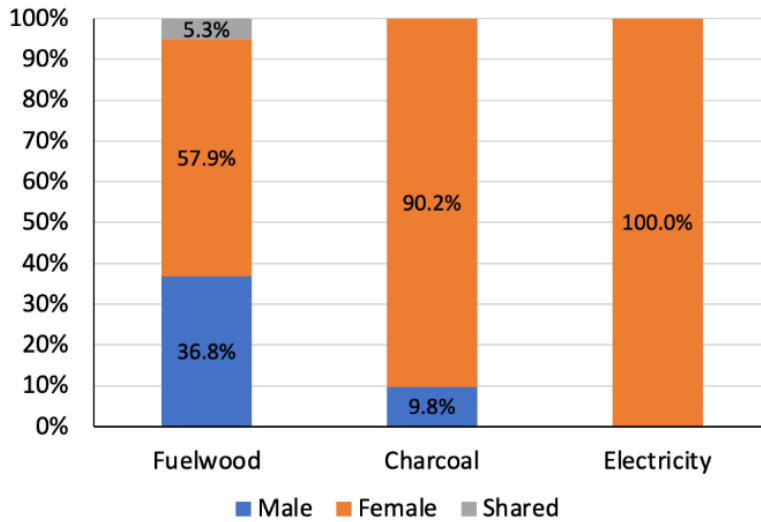


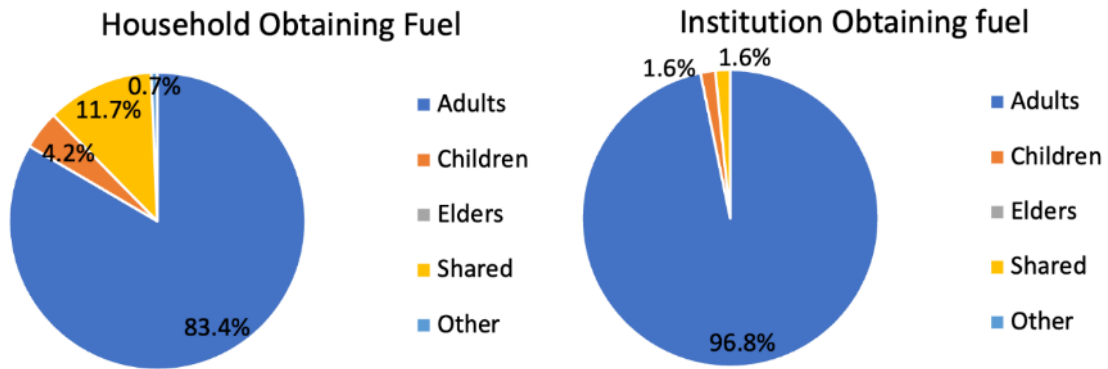
Figure 34. Gender of person obtaining fuel for institutions by fuel type

Gender of Person Obtaining Fuel for Institutions by Fuel Type



Adults are predominantly responsible for obtaining fuel for both households and institutions as shown in Figure 35. Children take on a small fraction of this responsibility for institutions, and this number is only marginally higher for households. The response for “shared” does not differentiate who shares this role and it is possible that children, elders, or both are included in that category alongside adults.

Figure 35. Age of person obtaining fuel for households and institutions



Figures 36 and 37 support findings that women are predominately responsible for cooking, and have a similar if slightly lesser degree of authority in budget management and deciding on cooking fuel. Institutional respondent data for budget management were not obtained due to errors in survey forms or enumerator collection. There are a few cases in which roles are shared between both men and women, but it is one or the other in almost all instances.

Figure 36. Gender implications in budget management, fuel selection and cooking for households

Gender Implications in Budget Management, Fuel Selection, and Cooking for Households

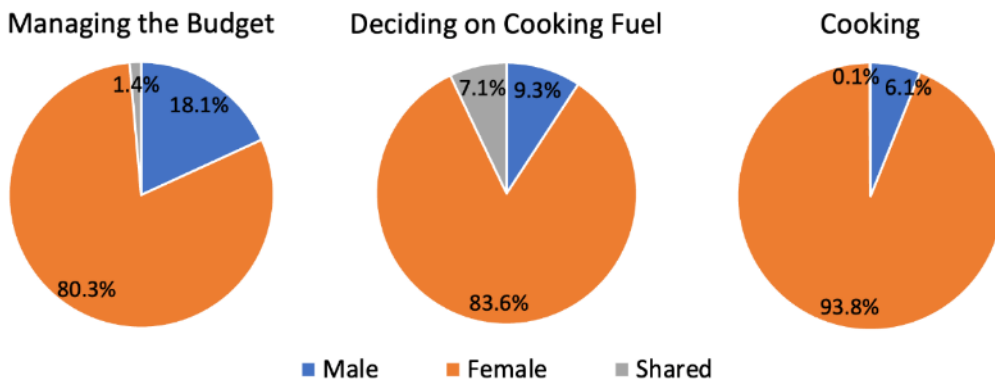
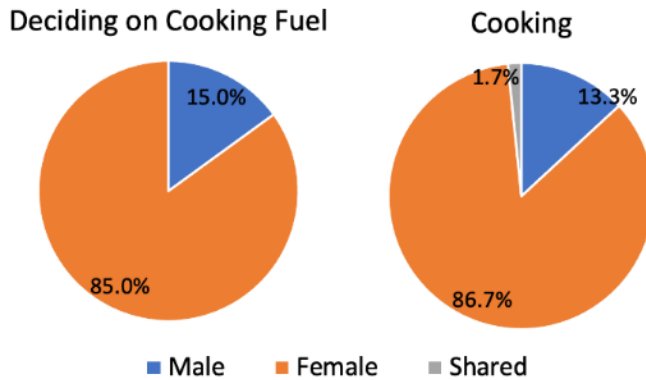


Figure 37. Gender implications in fuel selection and cooking for institutions

Gender Implications in Fuel Selection and Cooking for Institutions



Figures 38 and 39 show who cooks and their role within the household or institution, respectively. Household data were obtained using the demographics question with many categories, and this was categorized into adult, child and elder by assuming that child, grandchild and niece/nephew fall into a “children” category and that grandfather/grandmother fall into the “elder” category. Adults are the only group responsible for cooking in 73.2 percent of households surveyed and share that role with another group in 21.6 percent of households surveyed. A small but notable amount of 4.7 percent of households included children as the sole group responsible for cooking, and elders had responsibility for cooking in a minimal number (0.5 percent) of households. A similar question for institutions only gave the relationship of the individual and did not include information on their age.

Figure 38. Household cooking responsibility by age

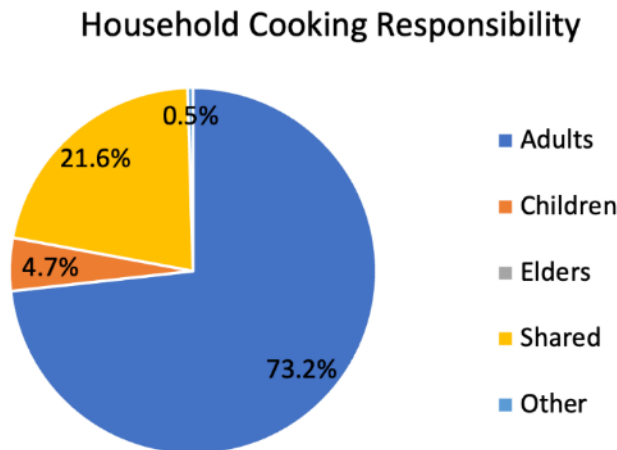
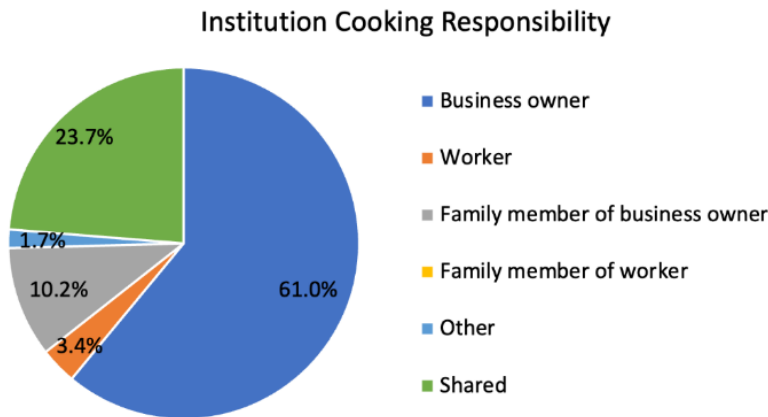
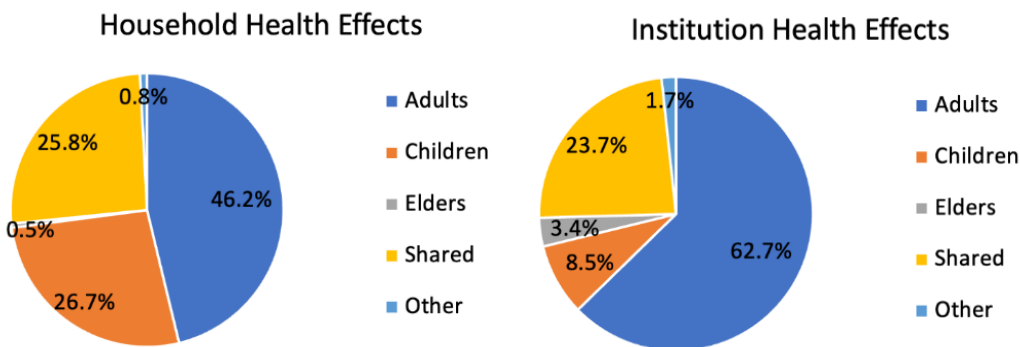


Figure 39. Institution cooking responsibility



Respondents believe cooking affects the health of more than just those individuals who are cooking. This is seen in their answers to the question: “Who is most affected by fire hazards, smoke inhalation, or other safety concerns related to cooking?” Figure 40 shows the number of respondents who include “children” and “shared” relative to the amount of non-adult categories included in Figure 38.

Figure 40. Age of person reported to experience most of the health-related effects from cooking



Time spent cooking is another metric of relevance for gender analysis. Figure 41 shows that owners of improved cooking technologies spend less time cooking in an average day than fuelwood and charcoal users; the former report one hour a day and the latter three and upwards. A similar trend is observed for electricity and LPG use for institutional respondents, though fuelwood and charcoal use is spread evenly across more hours of the day. Only a small percentage of households use fuelwood and charcoal stoves for six hours a day or more – 6.7 percent and 7.4 percent of households, respectively. The situation for institutions is quite different – 50 percent and 50.9 percent of respondents use fuelwood and charcoal, respectively, for six hours a day and more. This is shown in Figure 42.

Figure 41. Time spent cooking for households by fuel type

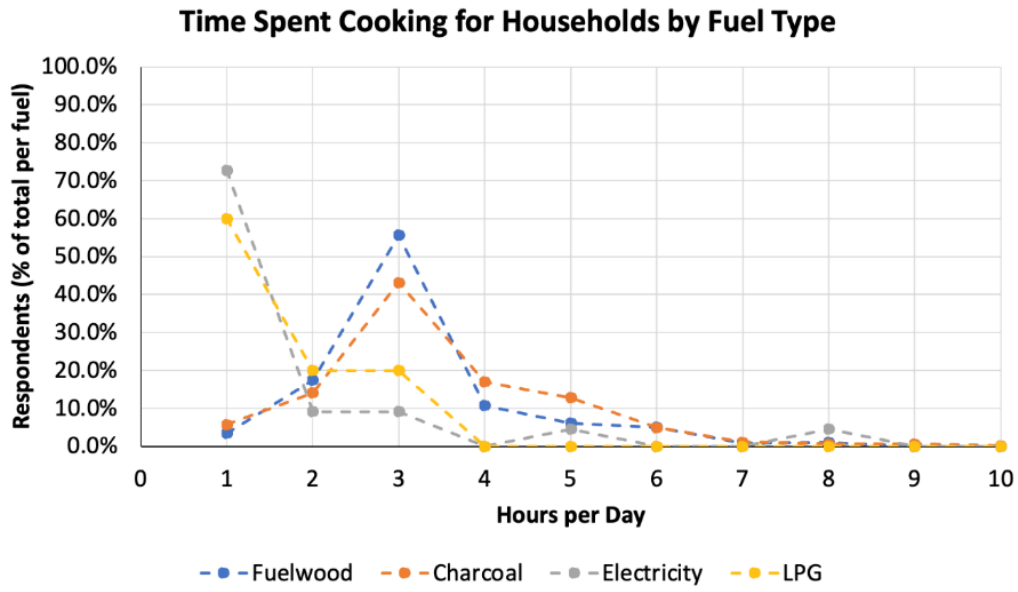
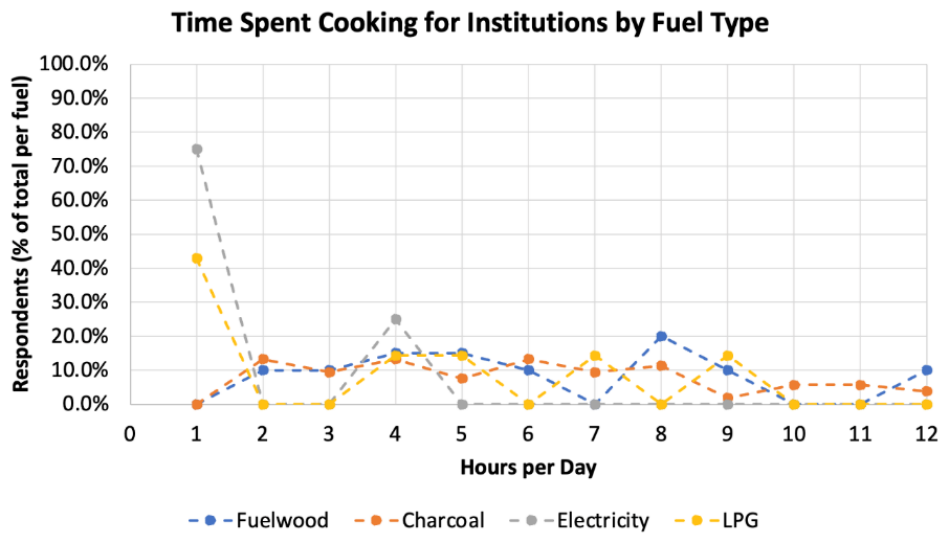


Figure 42. Time spent cooking for institutions by fuel type



ANNEX A - SURVEY INSTRUMENTS

Sent as separate PDFs

ANNEX B - COOKSTOVES AND FUELS

Sent as separate PDFs