ZAMBIA CLEAN COOKING STUDY (ZCCS)

BASELINE REPORT FOR IMPLEMENTING PARTNER SUPAMOTO

Prepared by the EPPSA and PEER Study Team[1]

February 2021

KEY TAKEAWAYS

- **37%** of households with a MimiMoto use it as their primary stove; **41%** use it as their secondary stove
- MimiMoto stoves are **not widely used for lighting or heating homes**
- MimiMoto users were using **1.1kg of charcoal less** per day than non-users at baseline
- Households who went on to purchase a MimiMoto had **higher income and expenditures at baseline**
- **Lower exposure** of primary cooks to carbon monoxide in households using MimiMoto stove, but no difference in exposure to fine particulate matter

BACKGROUND

In 2019, the Energy Poverty PIRE in Southern Africa (EPPSA) and Partnerships in Enhanced Engagement in Research (PEER) study teams[2] embarked on the Zambia Clean Cooking Study (ZCCS) in collaboration with SupaMoto, a social enterprise based in Lusaka, Zambia. SupaMoto markets clean energy solutions to households in Zambia. The ZCCS is a study of the impact of using SupaMoto's clean cooking solution: SupaMoto pellets (Figure 1a) and the MimiMoto fan microgasification cookstove (Figure 1b) on charcoal use, household expenditures on cooking energy, time allocation of household members for cooking, exposure to household air pollution, and self-reported indicators of health. This report provides a summary of analysis of baseline data collected in July and August of 2019 and a rapid follow-up conducted in March and April of 2020 in Lusaka, Zambia.

Figure 1: SupaMoto clean cooking solution

1a. SupaMoto biomass pellets

1b. MimiMoto fan micro-gasification cookstove

STUDY DESIGN AND SAMPLING

The study is a quasi-experimental quantitative impact evaluation. It takes place in two purposively selected high-density compounds in Lusaka, Matero and Kalingalinga **(Figure 2)**. The compounds, selected in collaboration with SupaMoto, are socio-demographically comparable neighborhoods where SupaMoto had already marketed their clean cooking solution, and had plans to market.

The two compounds represent two study arms at baseline – current customers residing in Matero Compound, and prospective SupaMoto clients in Kalingalinga Compound **(Figure 3a & 3b)**. The baseline study involved a detailed structured socioeconomic and health survey with questions answered by the main decision maker, typically the household head, and the primary cook in the household. At baseline, the primary cook in all study households was asked to participate in 24-hour monitoring of personal exposure to carbon monoxide (CO). Of those who agreed, a random subset was asked to also participate in personal exposure monitoring for fine particulate matter ($PM_{2.5}$).

Figure 2: Matero and Kalingalinga Compounds

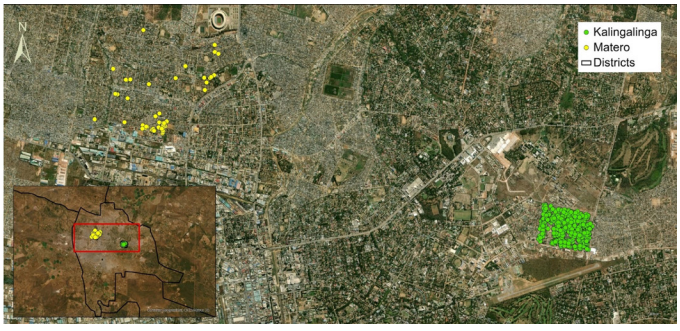
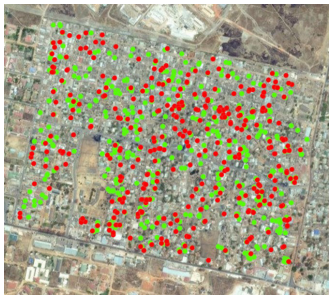


Figure 3: Location of study households – green households were surveyed, red households were in the sampling frame, but not surveyed.

3a. Matero Compound



3b. Kalingalinga Compound

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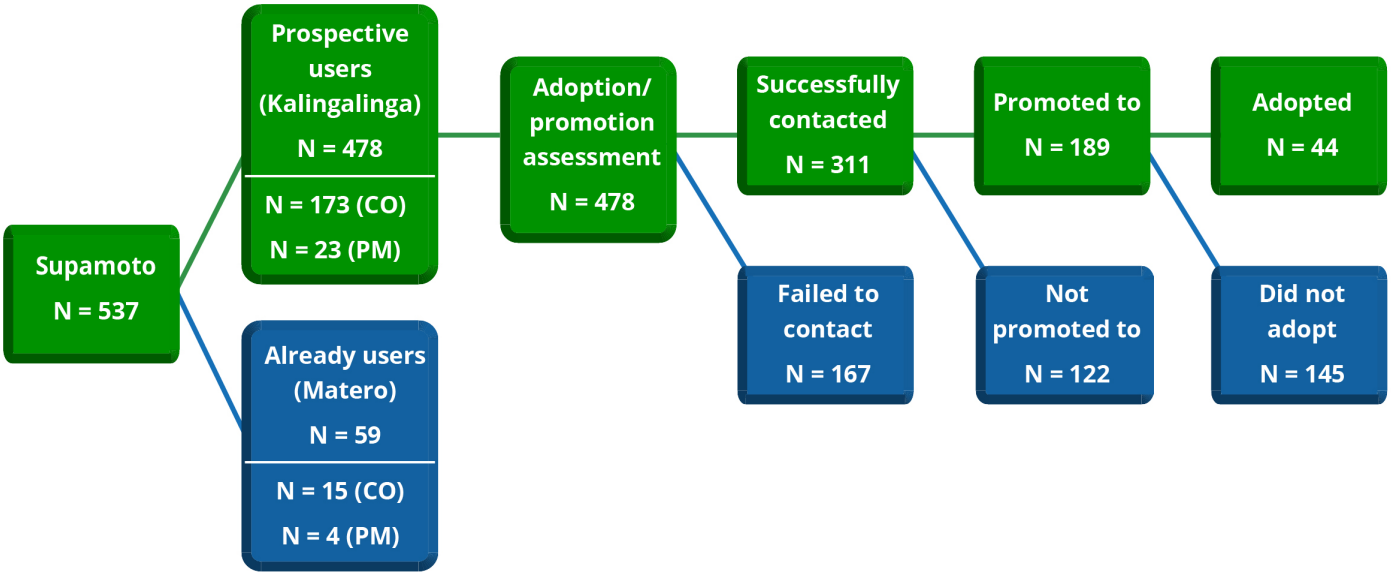
[2] The EPPSA team involves faculty and students from the Copperbelt University, University of North Carolina at Chapel Hill, University of Michigan, North Carolina State University, and RTI International. The PEER team involves researchers from the Centre for Energy, Environment, and Engineering, Zambia, the Stockholm Environment Institute, and Pennsylvania State University.

In early 2020, SupaMoto undertook a targeted marketing campaign in Kalingalinga Compound with the aim of marketing pellets and the MimiMoto stove to all households in the compound. There were two main activities: 1) promotion and 2) sales. Promotion goals included advertising the products and sales options to the population. Initially, in Kalingalinga but outside the study area, representatives went door-to-door advertising their product. After a period of violence and tension in the compound, door-to-door operations ceased due to safety concerns. At this time, an alternative promotion method was used, where a marked SupaMoto company vehicle was driven through the compound blaring music, accompanied by a promoter using a loudspeaker, and sales promoters in distinct bright orange outfits. The promoters walked behind the vehicle and informed potential customers about the product, payment plans, and purchasing locations that would be set up in the coming week. Following the promotion drive, sales locations were set-up in the compound in addition to the fourteen shops already present. Each day, after driving through the compound, teams set-up promotional fanfare at a permanent shop or sites where community members had signed on to be pellet re-sellers. New customers need to be traceable in case they fail to keep up with payments and the stove needs to be retrieved, so the sign-up process includes taking photos of the customer and going to collect a GPS location at their home. The photo and location are verified as customers pay their monthly installments.

In April 2020, the study team attempted to contact all of the 478 study households in Kalingalinga over the phone to ask them a brief set of questions about their awareness of SupaMoto and the MimiMoto stove, whether they had been promoted to, and whether they had purchased a MimiMoto stove. Thirty-one households could not be reached because the household did not provide a phone number during the baseline survey. Out of 447 households contacted by phone in April 311 (69%) were reached. Of these 311, 189 (61%) households were promoted to by SupaMoto, 44 (14%) purchased the MimiMoto stove, and 23 (7%) moved outside the compound making them no longer eligible for continued participation in the study. 23% of the 189 households that SupaMoto reached with their marketing campaign purchased a MimiMoto stove.

Endline data collection, involving an in-person household/cook survey and exposure monitoring originally planned for July 2020 is postponed due to the COVID-19 pandemic. Study arms and associated sample sizes are described in **Figure 4**.

Figure 4: Study arms and sample sizes



BASELINE SURVEY – SUMMARY OF FINDINGS

Household Demographics

Table 1 summarizes key household characteristics in each compound. It also compares households in Kalingalinga compound that adopted the MimiMoto stove and those that did not, based on data collected in April 2020.

There are several differences between the households in Matero and Kalingalinga. In Matero, households are on average larger, wealthier, have older heads of household and primary cooks, and have been in Lusaka for a longer time. Within Kalingalinga, the households that adopted the MimiMoto stove were larger, wealthier, and the occupants were more likely to own their home.

Table 1: Household characteristics, mean (standard deviation in parentheses)[1]

	Baseline Full Sample		Ng'ombe	
	Matero	**Kalingalinga**	**Adopters**	**Nonadopters**
Household size	5.90 (2.73)*	4.99 (2.78)*	5.82 (2.29)*	5.07 (2.13)*
Household head age (years)	46.68 (11.07)*	39.48 (14.25)*	44.44 (16.60)	41.14 (13.84)
Primary cook age (years)	38.93 (14.43)*	33.99 (13.08)*	36.36 (16.00)	36.11 (12.93)
Dependency ratio (independents:dependents)	2.41 (1.85)*	1.93 (1.41)*	1.82 (1.56)	1.98 (1.38)
Household Head years lived in Lusaka	26.23 (14.08)*	24.26 (14.24)*	32.33 (16.62)	30.61 (16.32)
Female head of household (%)	71.18 (46.67)	61.72 (48.66)	63.63 (48.66)	55.33 (49.88)
Highest grade attained (hh head)	9.77 (2.32)	9.53 (2.89)	9.78 (3.12)	9.37 (2.70)
Highest grade attained (cook)	9.96 (2.29)	9.10 (2.75)	9.58 (2.95)	8.59 (2.64)
Monthly household income (ZMK)	3070.02 (1687.99)*	2476.24 (1672.34)*	2957.24 (1838.26)*	2241.17 (1450.06)*
Home is owned by occupant (%)	54.24 (50.25)	30.96 (46.28)	47.73 (50.53)*	29.33 (45.68)*
Hh head marital status (%)				
Married	64.41	57.3	58.14	65.52
Never Married	5.08	19.1	13.95	13.79
Previously Married	30.51	23.61	30.23	20.69
Cook marital status (%)				
Married	51.72	50.84	43.18	61.07
Never Married	24.14	31.93	31.82	24.83
Previously Married	24.14	17.23	25	14.09
Single Family Dwelling (%)	32.30 (0.47)*	11.30 (0.32)*	13.64 (34.71)	10.00 (30.10)
Asset index score[2]*				
Poorest	5.08	16.11	4.55	19.33
Mid-poor	13.56	19.25	20.45	24.67
Middle	0	22.18	34.09	18.67
Mid-rich	15.25	21.97	11.36	26
Richest	66.1	20.5	29.55	11.33
N	**59**	**466**	**44**	**150**

[1] The asterisk (*) indicates that the two groups statistically differ at the 5% level.
[2] Percent of each subgroup falling within wealth population quintiles defined by the entire sample's asset index

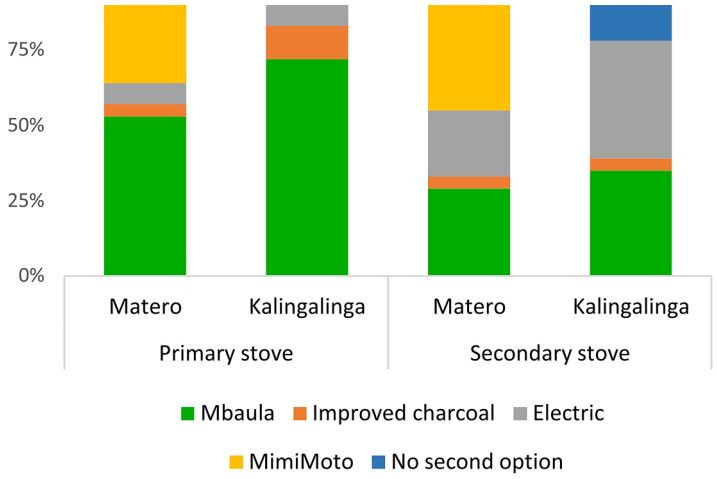
Baseline Energy Access in SupaMoto Study Compounds

This section presents the energy use profiles of households in Matero and Kalingalinga. **Figure 5** shows the primary and secondary stoves used by households in each compound, **Figure 6** shows the primary lighting source used by households, and **Figure 7** shows what households are using to heat their homes.

Cooking at Baseline

Figure 5 shows the cookstoves used by households in each compound. In Kalingalinga where households had not had an opportunity to purchase an improved stove, 72% of households were using charcoal as the fuel for their primary stove (53% using traditional mbaula; 37% using improved charcoal stove). The most commonly reported secondary stove was electric (39%) closely followed by a second traditional mbaula (35%). In contrast, in Matero only approximately 53% of households used charcoal as their primary stove/fuel choice. Thirty-seven percent of households in Matero reported using the MimiMoto as their primary stove and 41% use it as their secondary stove, which suggests approximately three-quarters of households with the MimiMoto are using it regularly.

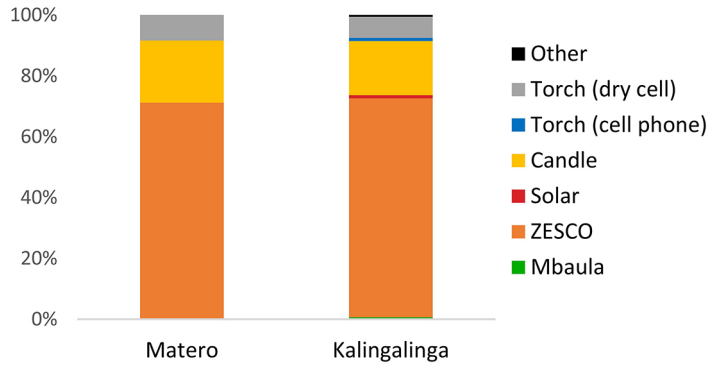
Figure 5: Primary and Secondary Cooking Stove



Lighting at Baseline

Figure 6 shows primary lighting source of households in the two study compounds. Most households in both compounds (88% in Matero; 90% in Kalingalinga) are connected to the national grid. Most of these households use electricity as the primary source of lighting in their homes (65% of all households in both compounds). Other commonly reported lighting sources in both compounds are candles and torches. There were no households reporting solar as the primary lighting source in Matero and only five in Kalingalinga (0.1%).

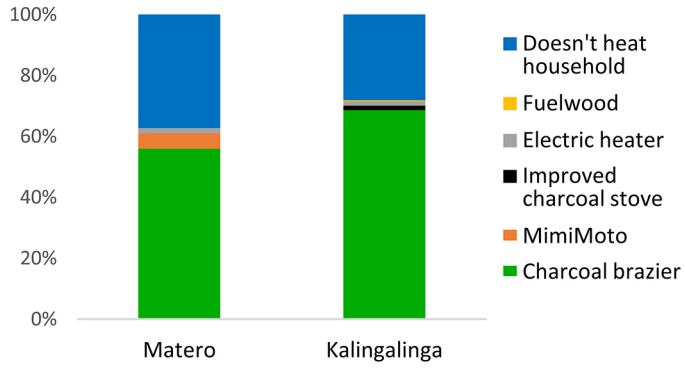
Figure 6: Primary Lighting Source



Heating at Baseline

In Matero, 63% of households heat their house during winter/cold season, 72% of households do so in Kalingalinga. **Figure 7** summarizes how these households heat their home. In both compounds, the primary source is the traditional mbaula (56% Matero; 61% Kalingalinga). Five percent of households in Matero use the MimiMoto to heat their homes.

Figure 7: Space heating



Household Economics

This section illustrates economic characteristics of the households. **Figure 8** shows the employment status of the heads of households, **Figures 9 and 10** detail the monthly income of households from different sources, and **Figures 11 and 12** show the expenditures of the study households each month. **Figure 13** looks specifically at the energy expenditures within the household, which relates closely to **Figure 14**, which shows the amount of charcoal used per household per day.

Employment Status

Figure 8 shows the employment status of the heads of household in each compound and also for the adopters and non-adopters of the MimiMoto within Kalingalinga. The majority of household heads in Matero are working either at a salaried position (15.3%) or are self-employed (42.4%). However, a large percentage (30.5% are unemployed). Similarly, in Kalingalinga, there are more people who are engaged in salaried work (20.9%), fewer who are self-employed (34.9%) and the unemployment rate is also slightly higher (34.5%). There are also interesting differences in employment between those who adopted the MimiMoto in Kalingalinga compared to those who did not. Adopters are more likely to be self-employed (34.9% of adopters vs. 22.8% of nonadopters) and less likely to be unemployed (32.6% of adopters vs. 34.5% of non-adopters). In Matero, 13.5% of households have members engaged in any aspect of the charcoal business, with 6% in Kalingalinga. The overwhelming majority of households that have a member in the charcoal business in both compounds are charcoal vendors.

Monthly Household Income

Figures 9 and 10 present the income of households in each compound in two different ways. **Figure 9** shows the share of income a household receives from different sources and **Figure 10** shows the actual ZMK amount received from each source. Across the board, the vast majority (over 85% of income in all cases) is cash income. Smaller amounts of income are coming from in-kind sources and remittances, but there are not large differences in the share of income coming from these sources.

Figure 10 shows us that income is higher in Matero relative to Kalingalinga and also it shows us that the income of households in Kalingalinga that adopted the MimiMoto is higher than those who did not. In fact, the average income of those who adopted MimiMotos in Kalingalinga is similar to the average income of households in Matero.

Figure 8: Employment status, head of household

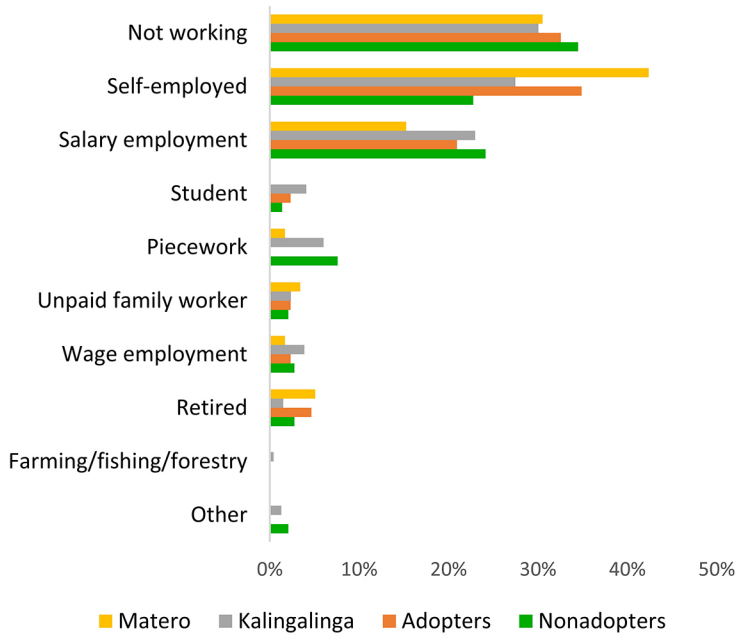


Figure 9: Share of household income from different sources

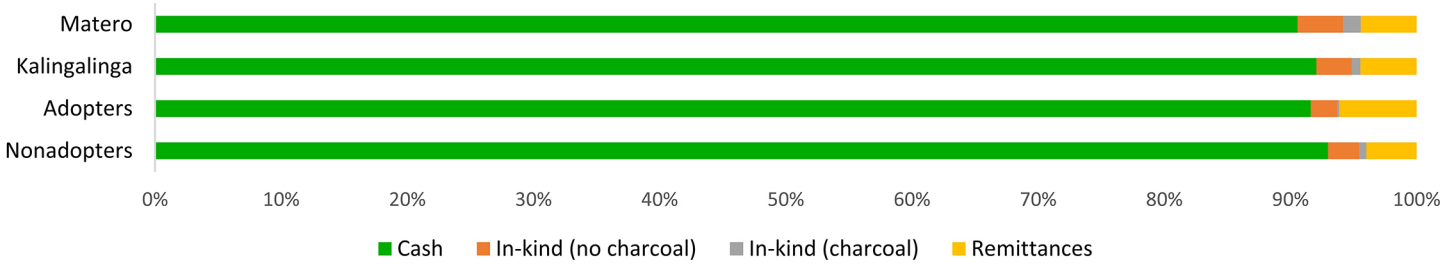


Figure 10: Total income (ZMK) from different sources

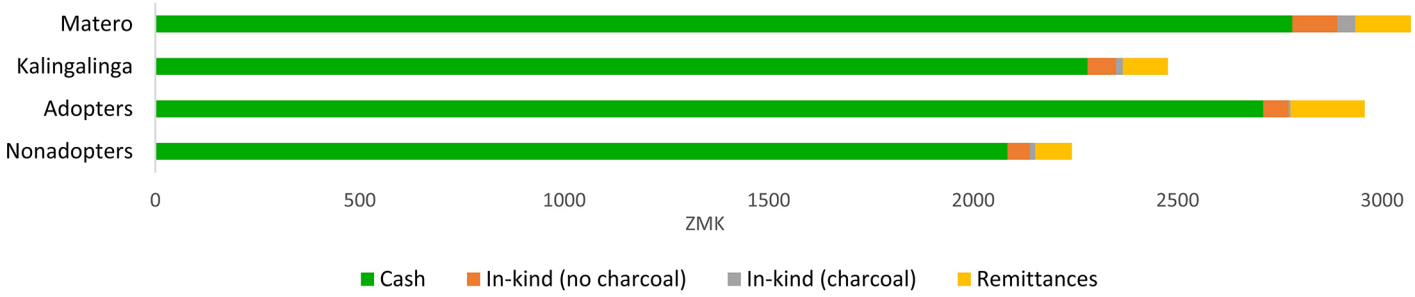


Figure 11: Monthly cash expenditure (share)

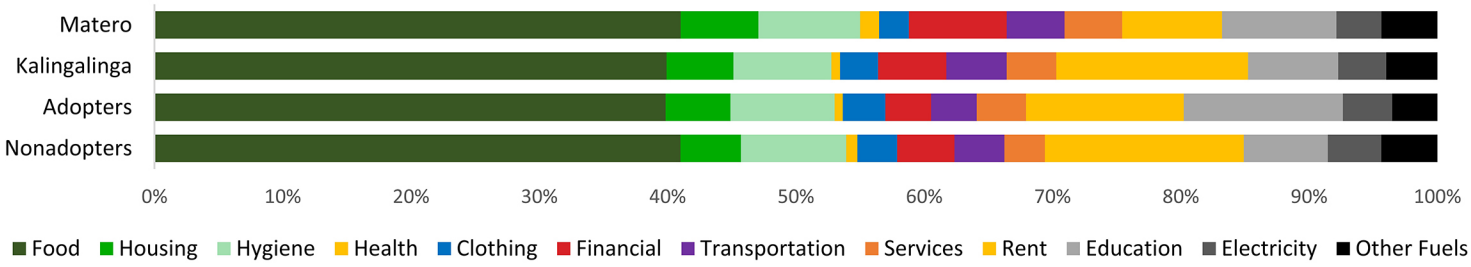
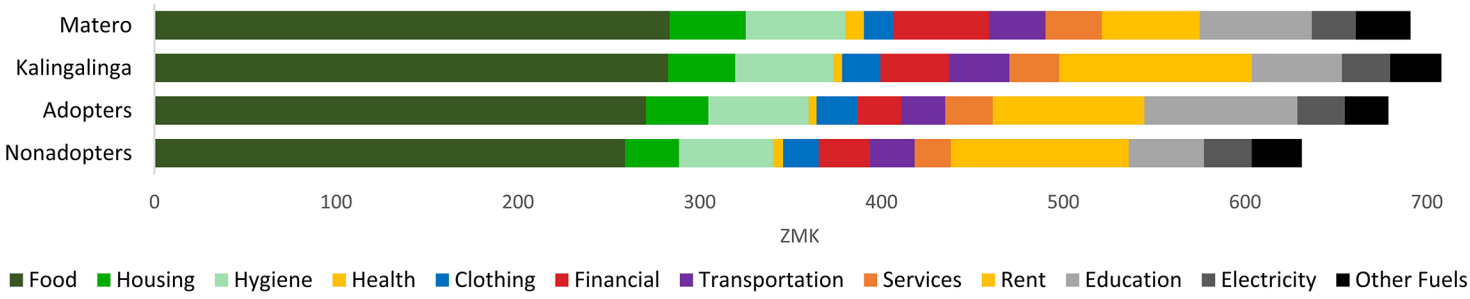


Figure 12: Monthly cash expenditure (total, ZMK)



Monthly Household Expenditures

Figures 11 and 12 show a broad picture of how individuals spend their money each month. Figure 11 shows the share of income a household spends on each category and Figure 12 shows the actual ZMK amount spent. Each category is the sum of many related purchases under that category. "Housing" and "Rent" are separate categories; "Housing" includes water and sewage charges, home repairs, cable/pay TV, and garbage collection, while "Rent" is simply what households are paying for rent each month. "Other Fuels" includes purchases for charcoal, firewood, paraffin/kerosene, diesel, LPG, batteries, light bulbs, lighters, pellets, and briquettes, among others.

We see from **Figure 11** that across all groups, the largest share of income is spent on food, with rent, education, and hygiene also making up large categories. Surprisingly, total expenditures are higher in Kalingalinga compared to Matero even though income is lower. The largest difference between the adopters and non-adopters group appears to be education with adopters spending more on education.

Energy Expenditures

Figure 13 depicts average energy expenditures in the past month on charcoal, pellets, and a combination of other fuels, which includes paraffin/kerosene, diesel, LPG, and briquettes. Total per capita energy expenditure is similar in Kalingalinga and Matero, and households in Matero are only spending slightly fewer ZMK per month per person on charcoal (24.21ZMK) compared to households in Kalingalinga that do not have a MimiMoto (26.48ZMK).

Figure 13: Monthly energy expenditures

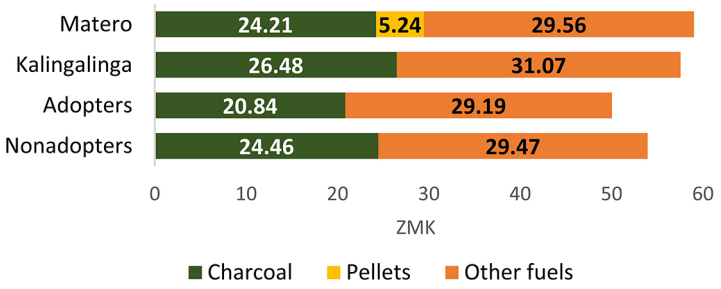
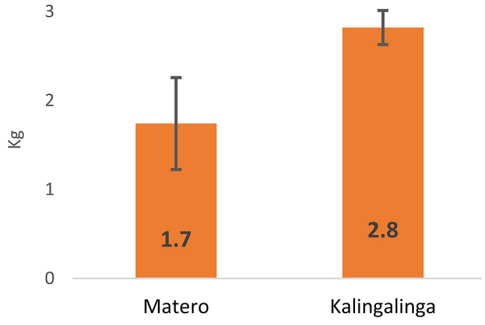


Figure 14 shows the average amount of charcoal used per day per household in each compound in kilograms. This suggests households in Kalingalinga use over 50% more charcoal than households in Kalingalinga.

Figure 14: Daily charcoal consumption per capita (kg)



Opinions about the MimiMoto stove

There are 59 households in Matero that were interviewed at baseline (July/August 2019) who were selected because they had purchased a MimiMoto stove. On average, they bought the stove 5.2 months prior to the time of the interview. They liked that the MimiMoto cooks faster and reduces household charcoal consumption since it does not use charcoal as fuel. Most people did not have anything negative to say about the stove. They also liked that the pellets are easy to use and that they cost less than charcoal, but they did not like the process of adding more pellets to the stove, or that you have to wait for all of the pellets to burn through.

Primary Cook Health

Figure 15 shows self-reported health symptoms of primary cooks in both compounds based on their primary stove. All MimiMoto users are from Matero, but those who report using traditional mbaulas and electric stoves might be from Matero or Kalingalinga. There are a higher proportion of cooks reporting all four symptoms, cough, eye irritation, headaches, and burns, in households using primarily a traditional mbaula. The proportion of cooks reporting symptoms when using a MimiMoto versus electric stove are roughly equal in all cases.

Carbon Monoxide and Particulate Matter Exposure Monitoring

Personal exposure monitoring (EM) of carbon monoxide (CO) and particulate matter with diameters less than 2.5 micrometers ($PM_{2.5}$) was conducted for 188 and 27 households, respectively across the two compounds. CO was measured using a Lascar USB Logger and $PM_{2.5}$ was measured using an RTI MicroPEM, both handheld, battery operated monitors. The primary cook of the household wore the monitors on their front torso for 24 hours. **Table 2** describes the breakdown of number of tests completed in each compound.

Twenty four-hour CO average exposures and daily CO trend are shown in **Figure 16A and B** for both compounds. Matero households had an average 24-hour CO exposure of 4 ppm, which is below the World Health Organization (WHO) 24-hour indoor air quality guideline of 6 ppm. Kalingalinga households had an average 24-hour CO exposure of 13 ppm, over three times higher than Matero households. The CO trend throughout the day was consistent for both compounds: small peaks around 10AM and 1PM and a larger peak at 8PM. The evening peak is consistent with use of stoves in tighter indoor environments for heating during cooler evenings.

Twenty four-hour $PM_{2.5}$ average exposures and daily $PM_{2.5}$ trend are shown in **Figure 17A and B** for both compounds. Matero and Kalingalinga households had average 24-hour $PM_{2.5}$ exposures of 80 and 105 μgm^{-3}, respectively, both above the WHO indoor air quality guideline of 25 μgm^{-3}. The $PM_{2.5}$ trend throughout the day was consistent for both compounds but different than the CO daily trend. $PM_{2.5}$ exposure peaked twice during the day, at 7AM and 7PM.

Figure 15: Primary cook health by stove type

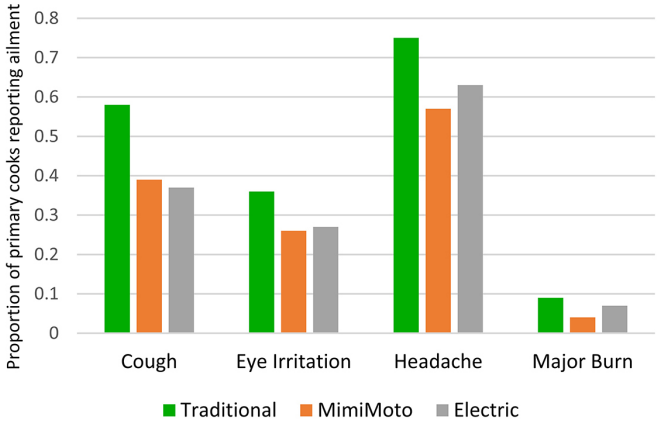


Table 2: Number of EM tests by compound and pollutant

Compound	CO Tests	$PM_{2.5}$ Tests
Matero (MimiMoto)	15	4
Kalingalinga (Baseline)	173	23

Figure 16: A) Twenty four-hour CO average exposures for both compounds. Boxes show 25th, 50th and 75th percentiles, whiskers show 9th and 91st percentiles, and diamonds show mean. (B) Daily CO trend. Lines show hourly median personal exposure concentration across all cooks and shaded regions show the 25th to 75th percentile range.

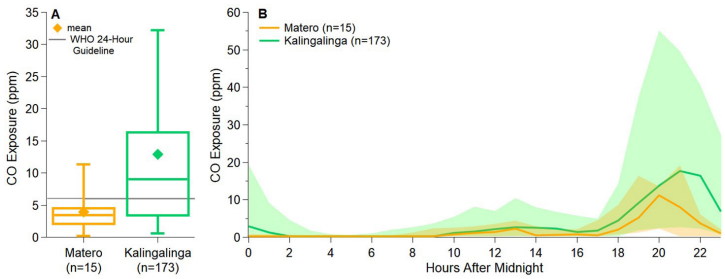
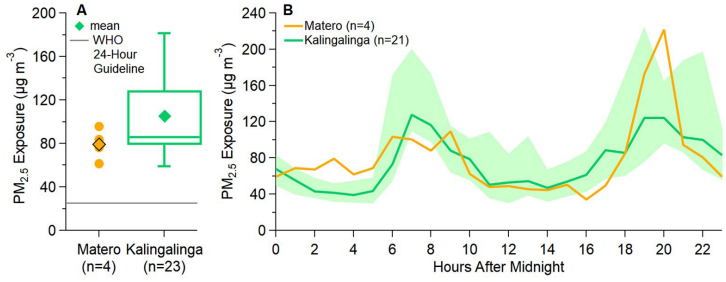


Figure 17: (A) Twenty four-hour $PM_{2.5}$ average exposures for both compounds. Boxes show 25th, 50th and 75th percentiles, whiskers show 9th and 91st percentiles, and diamonds show mean. (B) Daily $PM_{2.5}$ trend. For Kalingalinga, line shows hourly median personal exposure concentration across all cooks and shaded region shows the 25th to 75th percentile range. Because of the small sample size in Matero, only the average daily trend is shown.



FINANCIAL ANALYSIS

Table 3 shows the financial split out of SupaMoto's activities in 2019[3]. All figures are in millions of ZMK. While SupaMoto began as a cookstove company, they diversified into solar lighting as of 2018; this quickly became a large part of their business. Fixed costs, such as rent and labor, are shared between the two segments, and were split out using analysis of provided financials and consultation with SupaMoto. In 2019, the cookstove segment of SupaMoto's business had over 50% of both variable and fixed costs despite generating only 43% of the revenue. Some of this fixed cost difference comes from the cookstove business requiring more fixed costs in terms of operating the pellet factory.

Table 3: Financial Split out of Cookstove Business

Category	2019 – Overall	2019 – Just Cookstoves	2019 – Non Cookstove	2019 - Grants
Revenue	14.9	6.4	8.6	12.8
Variable Costs	7.7	3.9	3.8	
Gross Profit	7.3	2.5	4.8	
Fixed Costs	14.1	7.9	6.2	
EBITDA	-6.8	-5.4	-1.4	

All figures in Millions of Kwacha

Beginning at the end of 2018 SupaMoto began marketing their cookstoves in a different fashion; named the Yasha model, this new sales strategy by SupaMoto bundles solar products together with the cookstoves and moves from the previous pellet subscription model to one where the customer makes payments towards the stove and pellets separately, an individual customer breaks even about 15 months after purchase[4]. The breakeven point of any given transaction is when the revenue stream has covered the costs of the sale. This timeline is based on aggressive assumptions using the cheapest Yasha package, which at the time was the most popular, and current pellet profitability, while only considering the unit costs of the sale (the stove) without the institutional fixed costs such as the stores and salaries. Furthermore, it does not include financing costs or the costs of solar add-ons. 18+ months may be a more realistic breakeven point per customer when considering some of the additional unit costs (financing and solar add-ons).

At current Fixed Costs, the cookstove part of the business would break even with approximately 18,000 customers buying 20kg of pellets a month; at the time of interview in March of 2020 SupaMoto had approximately 4200 active stoves. Under the new Yasha model of ~30 sales per working day, this would take approximately 2.5 years to achieve from the end of 2019. This is conservative as it assumes fixed costs will not change substantially, as well as keeping pellet margins constant. This also does not consider sales stoppage due to Covid-19 and its effect on the growth of units.

3 This split was generated based on conversations with SupaMoto's accountants to attempt to split out fixed costs. Revenue and Variable costs are tracked separately by SupaMoto, while Fixed Costs must be abstracted based on these conversations.

4 This calculation is based on the best-selling Yasha plan, Yasha Compact, and assumes cost of stove at 67 USD, Pellet Margin of ~75%, and pellet sales of 20kg/customer/month.

NEXT STEPS IN STUDY

When it is safe to do so, the study team will return to collect endline data from all households. They will use the same survey instrument to collect information about households, and the exposure monitoring team will repeat their measurements of CO and $PM_{2.5}$ exposure. Once all data are collected, the results will be used for scholarly publications and to develop a series of short policy briefs for policy makers in the Health, Energy, Forestry, and Gender Ministries within the Government of Zambia.

ACKNOWLEDGEMENT OF FUNDERS & COLLABORATORS

The Energy Poverty PIRE in Southern Africa (EPPSA) is funded by the National Science Foundation (1743741) and the PEER study, Adoption and Scale-Up of Charcoal Alternatives in Zambia, is funded by the National Academies of Science (7-100). The EPPSA team involves faculty and students from the Copperbelt University, University of North Carolina at Chapel Hill, University of Michigan, North Carolina State University, and RTI International. The PEER team involves researchers from the Centre for Energy, Environment, and Engineering, Zambia (CEEEZ); Stockholm Environment Institute; and Penn State. We are grateful to the Carolina Population Center (P2CHD050924) at the University of Chapel Hill for general support of the study. We also would like to thank everyone at SupaMoto for their patient and continuous partnership during this study, and our team of hardworking enumerators, hired through Copperbelt University and CEEEZ.

The Zambia Clean Cooking Study was approved by the UNC Institutional Review Board (IRB). We also obtained approval from the Humanities and Social Science Research Ethics Committee (HSSREC) in Zambia. Study numbers are 19-0061 (UNC) and 2019-MAY-012 (HSSREC).

Citation: EPPSA and PEER Study Team. 2021. Zambia Clean Cooking Study (ZCCS):
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