

ZAMBIA CLEAN COOKING STUDY (ZCCS)

BASELINE REPORT FOR IMPLEMENTING PARTNER VITALITE



Prepared by the EPPSA and PEER Study Team¹

February 2021

Key Takeaways

- **88%** of households with an Ecozoom use it as their primary stove; **12%** use it as their secondary stove
- **32%** of households with an Ecozoom stove are also using it to heat their homes
- Ecozoom users were using **1kg of charcoal less** per day than non-users at baseline
- **No large differences at baseline in the income or expenditures** of households who adopt an Ecozoom stove versus those who do not
- **No differences between exposure** of primary cooks to carbon monoxide or fine particulate matter in households using an Ecozoom versus not

Background

In 2019, the Energy Poverty PIRE in Southern Africa (EPPSA) and Partnerships in Enhanced Engagement in Research (PEER) study teams¹ embarked on the Zambia Clean Cooking Study (ZCCS) in collaboration with VITALITE Ltd., a social enterprise based in Lusaka, Zambia. VITALITE markets clean energy solutions to households in Zambia. The ZCCS is a study of the impacts of using VITALITE's clean cooking solution: the Ecozoom stove (**Figure 1**) 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: VITALITE clean cooking solution



Study Design and Sampling

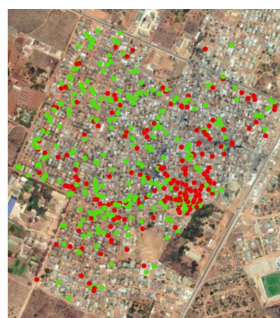
The study is a quasi-experimental quantitative impact evaluation. It takes place in two purposively selected high-density compounds in Lusaka, Kamanga and Ng'ombe (**Figure 2**). The compounds, selected in collaboration with VITALITE, are socio-demographically comparable neighborhoods where VITALITE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

The two compounds represent two study arms at baseline – current customers residing in Kamanga Compound and prospective VITALITE clients in Ng'ombe Compound (**Figures 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}.

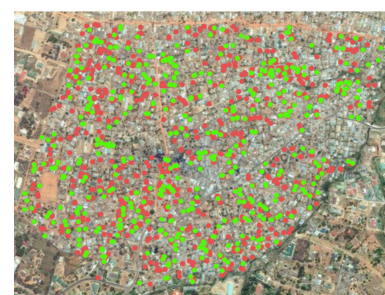
Figure 2: Ng'ombe and Kamanga compounds



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



3a. Kamanga compound



3b. Ng'ombe 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 late 2019, VITALITE undertook a targeted marketing campaign in Ng’ombe Compound with the aim of marketing the Ecozoom stove to all households in the compound. VITALITE representatives went door-to-door to households throughout the compound. If someone was home, they were told about the company and stove, then given a voucher (Figure 4), which offered the stove at a discounted rate. In order to purchase the stove, the household had to answer a short series of survey questions and be willing to sign a carbon contract.

In March 2020, the study team attempted to contact and revisit all of the 535 study households in Ng’ombe to ask them a brief set of questions about their awareness of VITALITE and the Ecozoom stove, whether they

had been promoted to, and whether they had purchased an Ecozoom stove. Out of the 535 households that the team attempted to contact, 444 (83%) were reached. Of these 444, 290 (65%) households were promoted to by VITALITE, 109 (25%) purchased the Ecozoom, and 31 (7%) moved outside the compound making them no longer eligible for continued participation in the study. Overall, 38% of the 290 households that VITALITE reached with their marketing campaign purchased an Ecozoom stove

Endline data collection, involving an in-person household/cook survey and exposure monitoring was originally planned for July 2020. Due to the COVID-19 pandemic, endline data collection has been postponed. Study arms and associated sample sizes are described in Figure 5.

Figure 4: VITALITE promotional voucher (example from Kamanga)

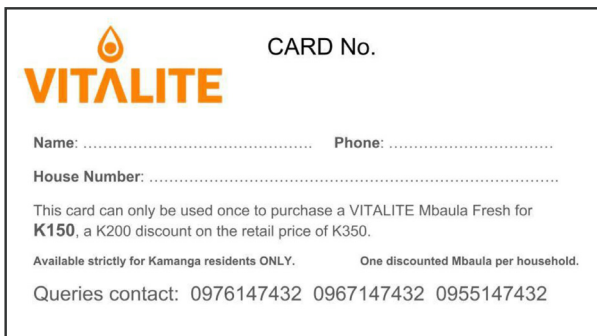
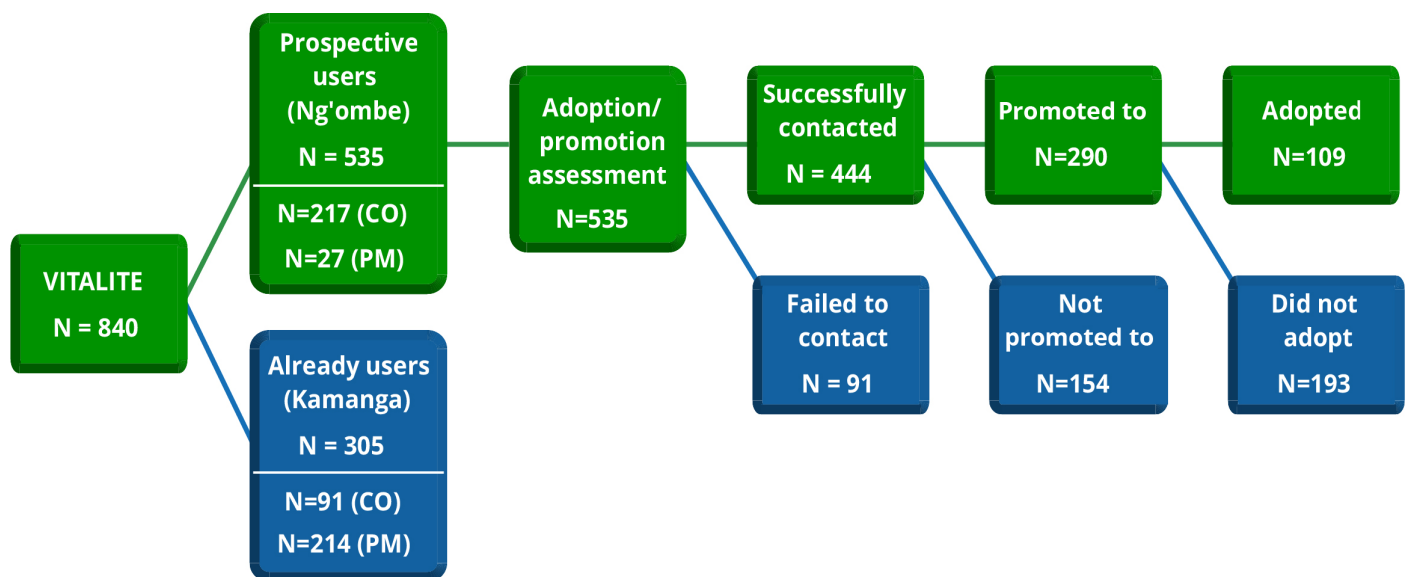


Figure 5: Study arms and sample sizes



Baseline Survey – Summary of Findings

Household demographics

Table 1 summarizes key household characteristics in each compound. It also compares households in Ng'ombe compound that adopted the Ecozoom stove and those that did not, based on data collected in March 2020.

There are several differences between the households in Kamanga and Ng'ombe. In Kamanga, households are wealthier, more likely to have a

female head of household, have older heads of household and primary cooks, and have been in Lusaka for a longer time. Within Ng'ombe, the households that adopted the Ecozoom stove were larger, have older heads of households and primary cooks, 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	
	Kamanga	Ng'ombe	Adopters	Nonadopters
Household size	5.56 (2.37)	5.24 (2.54)	6.33 (2.55)	5.11 (2.44)*
Household head age (years)	44.75 (13.61)	39.07 (13.56)*	46.03 (14.03)	38.92 (12.78)*
Primary cook age (years)	37.20 (13.84)	33.34 (12.42)*	37.56 (14.26)	33.51 (11.99)*
Dependency ratio (independents:dependents)	1.96 (1.45)	1.68 (1.31)*	1.85 (1.43)	1.72 (1.41)
Household Head years lived in Lusaka	25.42 (13.85)	21.49 (13.62)*	32.10 (13.70)	24.46 (15.08)*
Female head of household (%)	61.97 (48.63)	54.21 (49.87)*	61.47 (48.89)	55.96 (49.77)
Highest grade attained (hh head)	8.95 (2.97)	8.76 (2.84)	8.15 (2.77)	8.78 (3.02)
Highest grade attained (cook)	8.72 (2.84)	8.37 (2.86)	8.06 (3.02)	8.47 (2.83)
Monthly household income (ZMK)	2327.90 (1555.12)	1891.96 (1516.89)*	1769.12 (1292.71)	1782.65 (1435.86)
Home is owned by occupant (%)	50.16 (50.08)	33.46 (47.23)*	55.96 (49.87)	30.57 (46.19)*
Hh head marital status (%)				
Married	72.54	68.9	73.27	66.67
Never Married	4.75	11.61	6.93	13.11
Previously Married	22.71	17.52	19.8	20.22
Cook marital status (%)				
Married	60.87	64.04	66.98	63.02
Never Married	20.4	22.88	21.7	21.88
Previously Married	18.73	13.08	11.32	15.1
Single Family Dwelling (%)	20.66 (40.55)	11.59 (32.04)*	21.10 (40.99)	9.32 (23.16)*
Asset index score ^{2*}				
Poorest	8.2	31.96	11.01	30.57
Mid-poor	18.36	23.74	22.94	25.91
Middle	18.36	19.81	28.44	17.62
Mid-rich	23.93	16.45	27.52	15.54
Richest	31.15	8.04	10.09	10.36
N	305	535	109	193

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

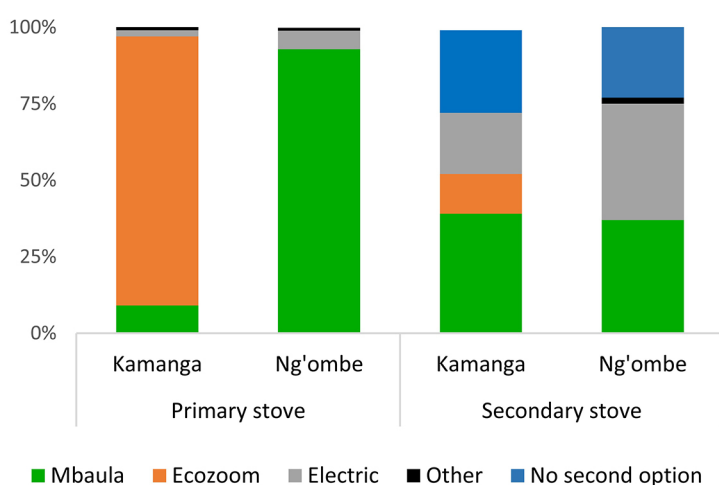
Baseline Energy Access in VITALITE Study Compounds

This section presents the energy use profiles of households in Kamanga and Ng'ombe. **Figure 6** shows the primary and secondary stoves used by households in each compound, **Figure 7** shows the primary lighting source used by households, and **Figure 8** shows what households are using to heat their homes.

Cooking at Baseline

Figure 6 shows the cookstoves used by households in each compound. In Ng'ombe where households had not had an opportunity to purchase an improved stove, 93% of households were using a traditional mbaula as their primary stove and the most commonly reported secondary stove was electric (38%) closely followed by a second traditional mbaula (37%). In contrast, in Kamanga only 9% of households used a traditional mbaula as their primary stove. Eighty-eight percent of households in Kamanga reported using the Ecozoom as their primary stove and 12% use it as their secondary stove, which suggests almost all households with the Ecozoom are using it regularly.

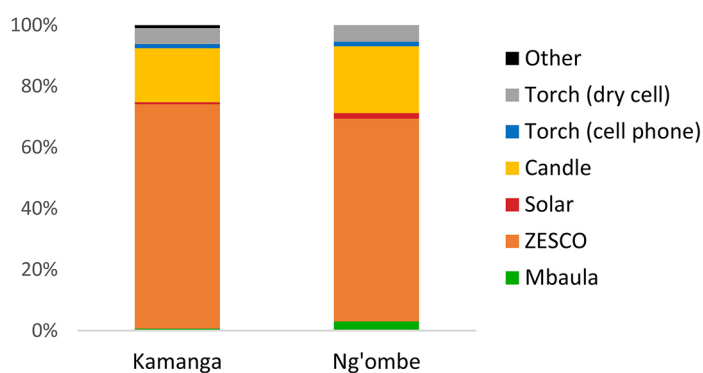
Figure 6: Primary and secondary cooking stove



Lighting at Baseline

Figure 7 shows primary lighting source of households in the two study compounds. Most households in both compounds (90% in Kamanga; 80% in Ng'ombe) are connected to the national grid. Most of these households use electricity as the primary source of lighting in their homes (75% of all households in Kamanga; 69% in Ng'ombe). Other commonly reported lighting sources in both compounds are candles and torches. There were no households reporting solar as the primary lighting source in Kamanga and only eight in Ng'ombe (0.15%).

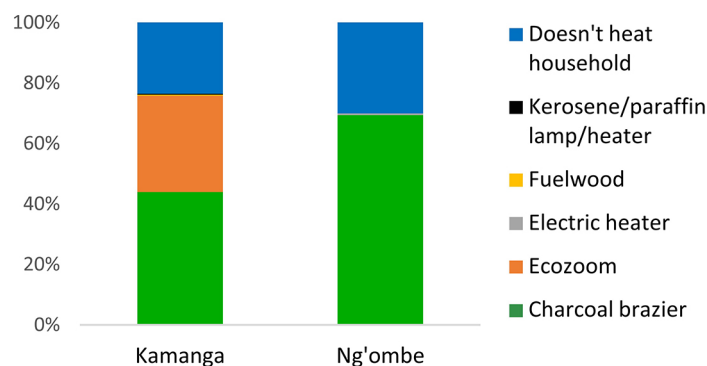
Figure 7: Primary lighting source



Heating at Baseline

In Kamanga, 76% of households heat their house during cold season, 70% of households do so in Ng'ombe. **Figure 8** summarizes how these households heat their home. In Ng'ombe, most households use a traditional mbaula (70%), but in Kamanga households are split between using an mbaula (44%) and an Ecozoom (32%).

Figure 8: Space heating



Household economics

This section illustrates economic characteristics of the households. **Figure 9** shows the employment status of the heads of households, **Figures 10 and 11** detail the monthly income of households from different sources, and **Figures 12 and 13** show the expenditures of the study households each month. **Figure 14** looks specifically at the energy expenditures within the household, which relates closely to **Figure 15**, which shows the amount of charcoal used per household per day.

Employment status

Figure 9 shows the employment status of the heads of household in each compound and also for the adopters and non-adopters of the Ecozoom within Ng'ombe. The majority of household heads in Kamanga are working either at a salaried position (19.3%) or are self-employed (35.3%). However, 30.8% of household heads are unemployed. Similarly, in Ng'ombe, there are more people who are engaged in salaried work (24.2%), the same amount who are self-employed (35.3%) and the unemployment rate is slightly higher (33.3%). There are also interesting differences in employment between those who adopted the Ecozoom in Ng'ombe compared to those who did not. Adopters are more likely to be self-employed (27.7% of adopters vs. 15.3% of nonadopters) but are less likely to be salaried workers (13.9% of adopters vs. 30.6% of nonadopters). The unemployment rates are very similar between the two groups (35%). In Kamanga, 8% of households have members engaged in any aspect of the charcoal business, with 7.5 in Ng'ombe. The overwhelming majority (85%) of households working in the charcoal business in both compounds are charcoal vendors.

Monthly Household Income

Figures 10 and 11 present the income of households in each compound in two different ways. **Figure 10** shows the share of income a household

receives from different sources and **Figure 11** 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 11 shows us that income is higher in Kamanga relative to Ng'ombe and that the income of households in Ng'ombe that adopted the Ecozoom is only slightly higher than those who did not.

Figure 9: Employment status, head of household

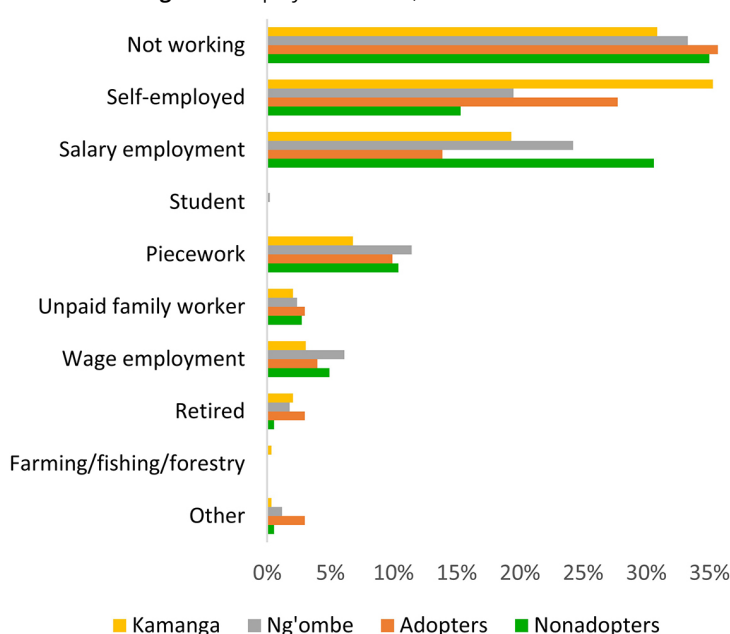


Figure 10: Share of household income from different sources

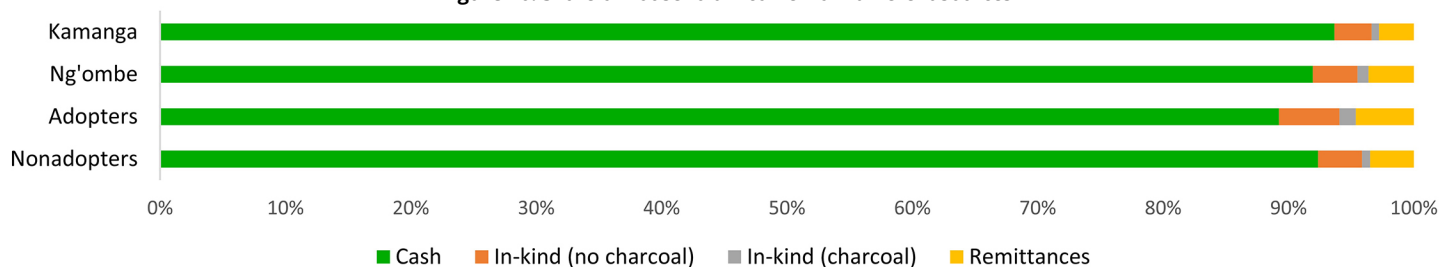
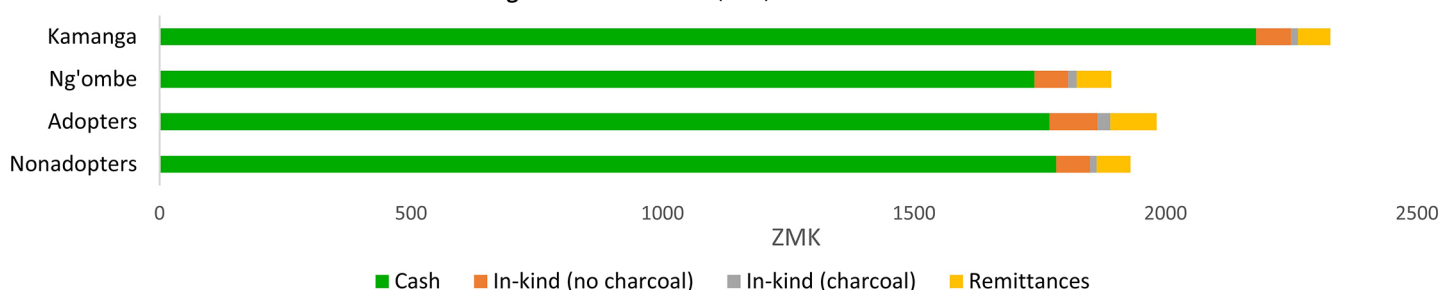


Figure 11: Total income (ZMK) from different sources



Monthly Household Expenditures

Figures 12 and 13 show a broad picture of how individuals are spending their money each month among a variety of categories. **Figure 12** shows the share of income a household spend on each category and **Figure 13** 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 12** that across all groups, the largest share of income is spent on food, with rent, education, housing, and hygiene also making up large categories. Total expenditures are higher in Kamanga compared to Ng'ombe even though income is lower. The largest difference between the adopters and non-adopters group appears to be education with non-adopters spending more on education.

Figure 12: Monthly cash expenditure (share)

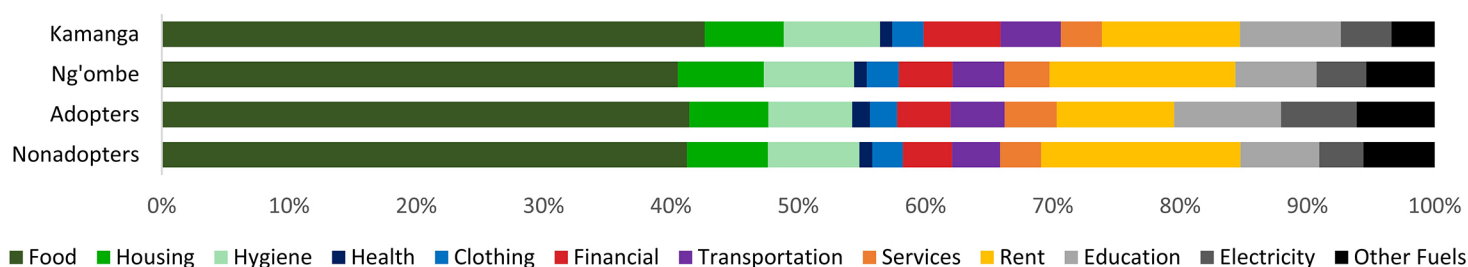


Figure 13: Monthly cash expenditure (total, ZMK)

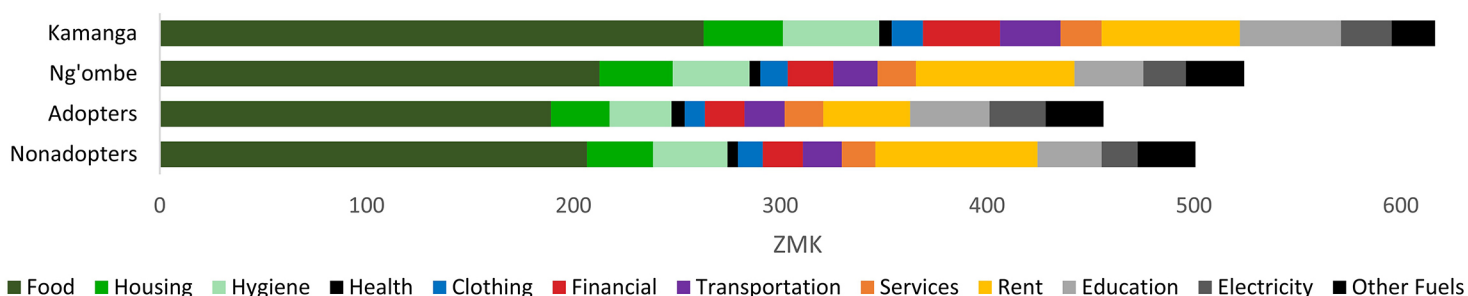
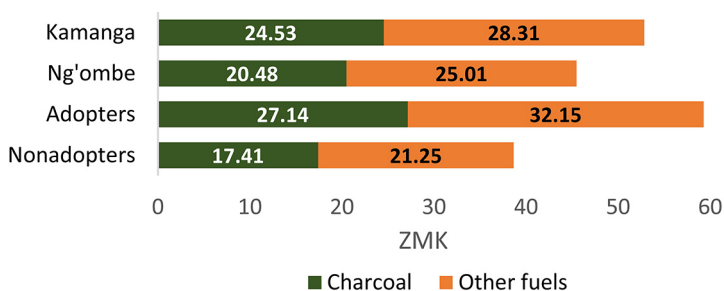


Figure 14: Monthly energy expenditures

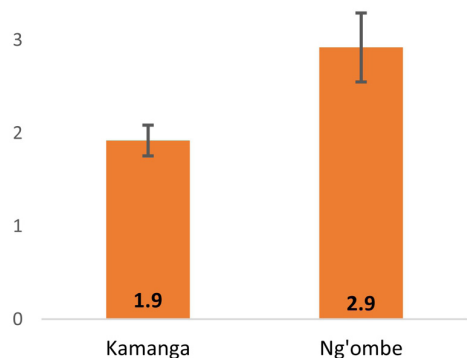


Energy Expenditures

Figure 14 depicts average energy expenditures in the past month on charcoal and a combination of other fuels, which includes paraffin/kerosene, diesel, LPG, and briquettes. Total per capita energy expenditure is slightly higher in Kamanga, and in fact, households in Kamanga are spending slightly more per month per person on charcoal (24.53ZMK) compared to people in Ng'ombe who do not have an Ecozoom (20.48ZMK). Prior to adoption, energy expenditures in the adopters group (59.29 ZMK) were much higher than in the group that did not adopt (38.66ZMK).

Figure 15 shows the average amount of charcoal used per day per household in each compound in kilograms. This suggests households in Ng'ombe use 1 additional kg of charcoal each day relative to the amount used by households in Kamanga.

Figure 15: Daily charcoal consumption (kg per person)



Opinions about the Ecozoom stove

There are 478 households that were interviewed at baseline (July/August 2019) who were selected because they had purchased an Ecozoom stove. On average, they bought the stove 2.6 months prior to the time of the interview. They liked that it reduces charcoal and cooks faster than a traditional mbaula and very few had anything that they disliked. Ninety-nine percent of Ecozoom users think that it reduces charcoal consumption.

Primary cook health

Figure 16 shows self-reported health symptoms of primary cooks in both compounds based on their primary stove. All Ecozoom users are from Kamanga, but those who report using traditional mbaulas and electric stoves might be from Kamanga or Ng'ombe. 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 Ecozoom 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 308 and 41 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 17A and B** for both compounds. Kamanga and Ng'ombe households had average 24-hour CO exposures of 19 and 18 ppm, respectively, both above the World Health Organization (WHO) 24-hour indoor air quality guideline of 6 ppm. The CO trend throughout the day was consistent for both compounds: small peaks around 9AM and 1PM and a larger peak at 9PM. The evening peak is consistent with use of stoves in tighter indoor environments for heating during cooler evenings.

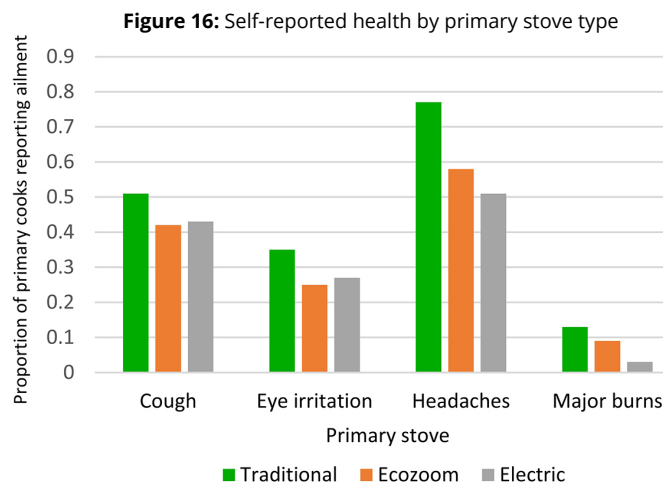


Table 2: Number of EM tests by compound and pollutant

Compound	CO Tests	PM _{2.5} Tests
Kamanga (Ecozoom)	91	14
Ng'ombe (Baseline)	217	27

Figure 17: (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.

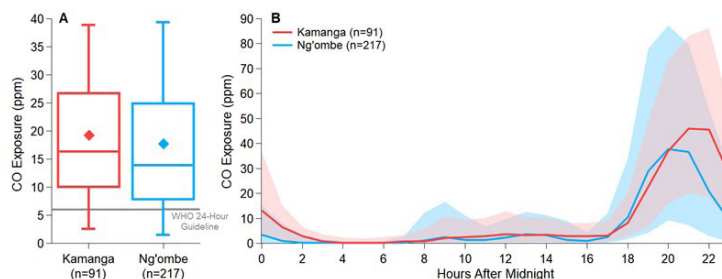
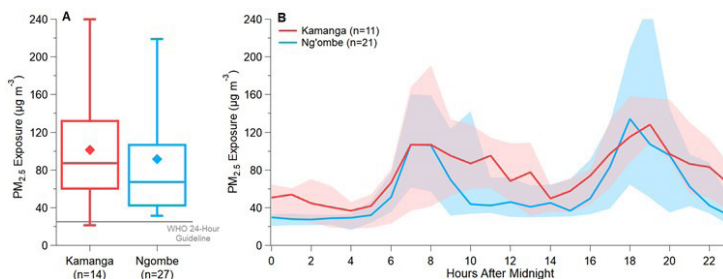


Figure 18: (A) Twenty four-hour PM_{2.5} average exposures for both compounds. Boxes show 25th, 50th and 75th percentiles, whiskers show 9th and 91st percentiles, and diamonds show mean. (B) Daily PM_{2.5} trend. Lines show hourly median personal exposure concentration across all cooks and shaded regions show the 25th to 75th percentile range.



Twenty four-hour PM_{2.5} average exposures and daily PM_{2.5} trends are shown in **Figure 18A and B** for both compounds. Kamanga and Ng’ombe households had average 24-hour PM_{2.5} exposures of 101 and 91 µg/m³, respectively, both above the WHO indoor air quality guideline of 25 µg/m³. 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.

Kamanga and Ng’ombe households had similar CO and PM_{2.5} exposures, with CO trends during the day consistent with mealtimes and stove use for heating at night. PM_{2.5} exposure is consistent with other sources aside from cooking that seem to dominate personal exposure. Ongoing analysis is exploring whether household distance from major roadways may influence exposure variation within and across compounds.

Financial Analysis

Table 3 shows the financial split out of VITALITE’s activities in 2019. All figures are in millions of ZMK. VITALITE began as a company primarily selling solar lighting and expanded to cookstoves in 2018. By 2019, cookstoves sales were not profitable at the unit level, i.e., the sale price did not cover the actual cost of the stoves, nor did they begin to cover the fixed costs required to sell the stoves. VITALITE operates as one business, and as such, fixed costs, such as rent and labor, are shared between the solar and cookstove businesses. Through analysis of VITALITE’s financials and consultation with VITALITE, the projections in **Table 3** use a conservative 15% allocation of overall fixed costs to cookstoves,³ rather than an even 50% split or a 7% split that the cookstove revenue would imply. This lack of profitability is exacerbated by the currently falling

Table 3: Financial Split out of Cookstove Business

Category	2019 – Overall	2019 – Just Cookstoves	2019 – Non Cookstove	2019 - Grants
Revenue	23.8	1.6	22.2	11.1
Variable Costs	16.6	2.1	14.5	
Gross Profit	7.1	-0.6	7.7	
Fixed Costs	14.1	2.3	11.8	
Net Earnings	-7.0	-2.9	-4.1	

All figures in Millions of Kwacha

³ This 15% figure is a conservative split. VITALITE Management suggested in conversation a more even split between the two businesses.

value of the Kwacha relative to the USD, the currency in which stoves are purchased. In 2019 the firm received some relief in the form of a large grant allowed them to sell stoves for 150 ZMK, a 200 ZMK discount off the regular price of 350 ZMK. However, in the future it may be difficult for VITALITE to continue selling the stoves at the current prices without offering a price reduction. Based on these calculations VITALITE would need to receive grants

equivalent to 75-150 ZMK per unit sold in order to break even. In the interviews with VITALITE, they expressed that since they give equal effort at the head office level to cookstoves and solar, the fixed costs should be divided equally. While this may demand equal effort (i.e., 50% of salary), cookstoves only make up 7% of sales.

Next Steps

When it is safe to do so, the study team will return to collect Endline data collection 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 (CEEZ); 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 VITALITE for their patient and continuous partnership during this study, and our team of hardworking enumerators, hired through Copperbelt University and CEEZ.

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).



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