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ALTERNATIVES TO CHARCOAL (A2C)
MARKET ANALYSIS REPORT

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Cover photo: Actress Wanga Zulu promoting alternative cooking technologies.
Credit: USAID Alternatives to Charcoal (A2C)

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ACRONYMS AND ABBREVIATIONS

A2C	Alternatives to Charcoal
ATF	Alternative Technologies and Fuels
CCA	Clean Cooking Alliance
CDM	Clean Development Mechanism
EBA	Exclusive Brands Africa
ERB	Energy Regulation Board
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GRZ	Government of the Republic of Zambia
ICS	Improved Cookstove
kg	Kilogram
kWh	Kilowatt hour
LPG	Liquefied Petroleum Gas
MOE	Ministry of Energy
MSME	Micro, Small, and Medium Enterprise
MW	Megawatt
NEFCO	Nordic Environment Finance Corporation
NGO	Non-Governmental Organization
OMC	Oil Marketing Company
PAYGO	Pay-As-You-Go
SADC	Southern African Development Community
SE4All	Sustainable Energy for All Initiative
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollar
VAT	Value-added Tax
ZRA	Zambia Revenue Authority
ZMW	Zambian Kwacha

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1. EXECUTIVE SUMMARY

Building from a series of initial private sector focus group discussions the Alternatives to Charcoal project (A2C) has undertaken a Market Analyses with the aim of providing market information, which can be used to overcome barriers to expansion of alternative technologies and fuels (ATFs). This market analysis includes both desk and field-based research and focuses on liquified petroleum gas (LPG), electricity, biomass, and ethanol. It also draws on lessons from markets in other countries. It has been structured around the Market Systems Assessment Framework developed by Practical Action which provides a common framework for systematically analyzing a range of energy market systems; and has also been informed by the Consumer Preference Study and Regulatory Review recently completed by A2C.

The Republic of Zambia is a landlocked country in the center of southern Africa. With an estimated population of 18.8 million people, the country spans 752,612 square kilometers (World Bank, 2018). Zambia is one of the most urbanized countries in sub-Saharan Africa, with 44% of its population living in a few urban areas, mainly in Lusaka and Copperbelt Province, whose cities represent the core economic hubs of the country (World Bank, 2018). Africa's second-largest copper producer, Zambia achieved middle-income country status in 2011, during a decade (2004–2014) of impressive economic growth (World Bank, 2019). In urban areas, most households use charcoal for cooking (59%), followed by electricity (34.5%), while LPG use is currently minimal (0.1%). Other ATFs, such as improved cookstoves (ICS), have less than 1% penetration in both urban and rural households.

The LPG market in Zambia is dominated five companies that hold 70% of the total market share. Two critical pieces of infrastructure at the start of the LPG value chain are ageing: the Tazama pipeline transporting petroleum feedstock for Zambia's sole oil refinery and Indeni Oil Refinery. At the time of writing, Indeni had been offline for nine months due to halted maintenance caused by financial constraints, as well as insufficient supply of petroleum feedstock. Due to these operational challenges, LPG production has fluctuated over the last 10 years from a low of 3,740 tons (2015) to a high of 11,809 tons (2012). During this 10-year period domestic consumption has steadily increased to a high of 7,945 in tons (2020). In every year, apart from 2020, domestic production of LPG has exceeded consumption. However, Zambia has been dependent on imports since December 2020, which has increased the price, drastically impacting businesses.

There are four primary retail channels for LPG in Zambia, which include physical premises, petrol stations, kiosks/containers and home delivery. In practice, many retailers are implementing a number of these at the same time. Many smaller LPG retailers operate under a kiosk model. Through this model an entrepreneur can apply to become an LPG distributor through an oil marketing company (OMC) who is already licensed by the Energy Regulation Board (ERB), making market entry more flexible. Due to the difficulty in accessing financial support for small scale businesses, the source of funding for kiosks is often through personal finances. As such, the need for financing cannot be over emphasized. Generally, the tax and regulatory status in the industry is favorable with retailers able to promote LPG under the license of their OMC supplier and taxes waived on all LPG products, except cylinders. However, the price of LPG has significantly increased over the last 2-3 years. This price increase has been driven by two factors. Firstly, the Zambian Kwacha (ZMW) has weakened as compared to the US dollar. Secondly, towards the end of 2020, Indeni Refinery went offline forcing OMCs to import greater amounts of LPG. Effectively, during this three-year period, the price of LPG has doubled. Several innovations are emerging on the market such as home delivery services and mobile based applications that allow consumers to order LPG on the go.

Zambia has about 6,000 MW of unexploited hydropower potential, while only about 2,400 MW has been developed to date. However, over the last five years Zambia has been experiencing significant and

disruptive load shedding. Zambia's Sustainable Energy For All (SE4ALL) Action Agenda sets out a vision for modern and clean cooking solutions in urban areas by 2030. This vision follows a 20-40-20-20 scenario that aims to move urban cooking to 20% electricity, 40% LPG, 20% charcoal and 20% firewood. This would necessitate reducing electric cooking from 35% and charcoal use from 59% (2015), while increasing use of LPG from <1% and firewood from 6%. However, the Action Agenda does recognize that it is highly likely that electricity will remain the preferred source of energy for cooking in urban areas in the short to medium term but predicts this will shift in favor of other alternatives, as electricity tariff adjustments take effect, pushing the cost of electric cooking up. In 2019, Zambia increased its electricity tariffs to better reflect the cost of generating, transmitting, and retailing electricity. However, even with the significant increase in cost, Zambia's average tariff is still the second lowest in the region and regarded as not economically viable, putting pressure on ZESCO the state utility. The pending Cost of Service Study is anticipated to set-out a pathway for further tariff increases.

Connection rates in urban areas are high but shift in line with income levels with 61% of low-cost households connected, as compared to 91% of high-cost households. In total, 679,492 households are connected in Lusaka and Copperbelt provinces (2015 figures). Average household electricity usage is estimated to be 2.5 kilowatt hours (kWh) per day. Approximately 60% of household electricity demand is for cooking, and according to ZESCO, the highest consumption occurs during peak hour (19:00) when most households are preparing dinner. Electric cooking is the most popular ATF in Zambia, driven by historically low electricity tariffs and high connection rates, particularly in urban areas. Electric cooking appliances in Zambia are widespread and include a range of different technologies, providing several different services and covering numerous price points. However, recent tariff increases, and significant load shedding have driven some households back to cooking with charcoal and have led the Government of the Republic of Zambia (GRZ) to prioritize alternatives, such as LPG, for cooking. ZESCO has embarked on information dissemination campaigns to encourage users to choose other times for cooking meals and to practice a 'switch and save' system of electricity usage to ensure the grid is not overburdened.

Ethanol use for cooking in Zambia is still at a nascent stage, but there is significant potential to move households in urban areas away from solid fuels to ethanol. Shifting to ethanol cooking would provide Zambia with greater energy security, as opposed to LPG, which needs to be imported, while ethanol has zero impact on balance of payments and use of foreign currency. However, the sector in Zambia is very nascent. At the time of writing one company is intending to commence large-scale production of ethanol from casava feedstock for blending with petrol to meet the E10 mandate. Although not constructed yet, the plant is designed to produce 120 million liters of bioethanol per annum. Two more companies are in the process of setting up commercial biorefineries in Central province. While there are also a few small-scale producers with less than 1 million liters annual production.

Approximately 29 million liters of ethanol could be produced from existing molasses. While household consumption of ethanol would likely be in the region of 258 liters annually, equating to a potential market size of112,403 households. A retail price (excluding value-added tax; VAT) of $0.77 per liter has been estimated, resulting in a monthly household expenditure of $17. Currently, ethanol gel fuel is retailing at $2.10 for 750ml, while existing small scale ethanol producers in Zambia are retailing liquid ethanol at $0.9 per liter. For ethanol as cooking fuel to reach the market several significant investments will be required at every stage of the distribution network. At the refinery stage, to establish an ethanol plant capable of producing 29 million liters a year from molasses, an investment in the region of $20.89 million is required. Based on estimates from Kenya, an investment in the region of $1.9 million is needed for the establishment of depots, procurement of small tankers and the installation of retail points. Alongside the distribution network it would be critically important to factor in three months strategic fuel stock in case of shortages, equating to $2.7 million tied up in working capital for ethanol reserves. Finally, the working capital needs of stove retailers would be in the region of $600,000.

Using the methodology developed under the Nordic Environment Finance Corporation (NEFCO) Clean Cooking Market Assessment in Zambia, we estimated theoretical affordability and market size for ATFs. Two plate electric hotplates, ethanol gel stoves and double ethanol liquid stoves are the most affordable options on the market, with 1.5 million households being able to purchase one immediately using their estimated monthly cooking fuel expenditure. LPG single burners are the most affordable LPG appliance, with 0.7 million households able to purchase one immediately. Two plate electric cooker with oven, two burner LPG stove, and the electric pressure cooker all followed the same pattern, as they are at similar price points. For these appliances, 0.7 million households would need to save for three months to purchase one. Due to its price point, and the short financing terms used in this analysis, the gasifier stove is only affordable to 0.7 million households, based on saving for three months. However, the main gasifier stove supplier in Zambia is currently offering attractive financing terms of 35 months to make the stove more affordable, which increases the potential addressable market. At the top end of the market, the LPG four burner with oven, the four-burner combi gas/electric with oven and the four-plate electric with oven all also followed the same pattern. Due to their high cost, they were only affordable to 0.7 million households based on financing, Finally, biogas systems are unaffordable to all households, unless financing options longer than 6 months are available.

Funding needed to achieve universal access to modern energy cooking services by 2030 is estimated to be $150 billion annually, however only $70 million was raised in 2019 by the 25 clean cooking companies tracked by the Clean Cooking Alliance. To grow, ATF companies need access to funding and investment that allows them to scale their operations. Given the high interest rates and risk adverse nature of commercial Zambian banks towards micro, small, and medium enterprises (MSMEs), it is clear that many ATF companies will need to draw from other sources of investment if they are to attract the funding required. OMCs, however, are the exception. These large-scale companies already have established relationships with commercial lenders in Zambia and have the required collateral to access debt financing. But many smaller LPG retailers cannot demonstrate the same financial clout as their OMC suppliers and consequently lack financing to expand their retail outlets. These retailers often rely on their own funds, or those of family and friends to start and expand their businesses.

Viable financing alternatives identified in this assessment include crowdfunding, donor backed venture funds and carbon finance. In 2017, cookstove companies reported just over US$500,000 in carbon revenues, representing 1.2% of total revenues. However, this increased to US$ 5.2 million, or 12% of total revenues, in 2019. Almost all of the carbon revenues generated between 2017 and 2019 were by biomass stove manufacturers as part of the Clean Development Mechanism (CDM) or voluntary carbon market. Carbon revenues in the coming years are expected to increase even more, considering the emergence of the South Korean Emission Trading Scheme, and the upcoming dialogue on Article 6 of the Paris Agreement. At least four existing Gold Standard Programs of Activities have been identified in Zambia, which may be open to ATF companies to join.

Finally, a comparison of greenhouse gas emissions from both the charcoal and liquid petroleum gas (LPG) value chains is included in Annex 1. The purpose of the Annex, requested by USAID, is to compare the respective carbon footprints of charcoal and LPG to inform USAID's decision to promote LPG as an alternative fuel to charcoal in Zambia. It finds that the total emissions resulting from a household's cooking with LPG are expected to be about 58% less than the total emissions that would result if the same household were instead cooking with charcoal.

2. INTRODUCTION

The Republic of Zambia is a landlocked country in the center of southern Africa. With an estimated population of 18.8 million people, the country spans 752,612 square kilometers (World Bank, 2018). For every square kilometer of Zambian territory, there is an average of 23 people. Zambia is one of the most urbanized countries in sub-Saharan Africa, with 44% of its population living in a few urban areas, mainly in Lusaka and Copperbelt Province, whose cities represent the core economic hubs of the country, while the rural areas remain sparsely populated (World Bank, 2018). Africa's second-largest copper producer, Zambia achieved middle-income country status in 2011, during a decade (2004–2014) of impressive economic growth (World Bank, 2019). In 2017, the gross domestic product (GDP) per capita amounted to$1,513 (World Bank, 2018). However, the economic growth of 2004 2014 only benefitted a small segment of the urban population and had limited impact on poverty. As a result, the country ranks among those with the highest level of inequality globally (World Bank, 2019).

The primary sources of energy in Zambia are hydro, biomass, coal, wind, geo-thermal, solar, uranium, waste (including municipal solid and agricultural waste) and petroleum. Zambia is confronted with an increasing energy demand, resulting from demographic and socioeconomic factors, at an average of 6 percent or 150-200 megawatts (MW) per annum. Zambia has a hydropower potential in excess of 6,000MW out of which about 2,354MW has been developed. At household level, an estimated 67.3 percent of households in urban areas and about 4.4 percent of households in rural areas have access to electricity, translating into 31.4 percent at national level. Biomass is the predominant source of energy in Zambia accounting for more than 70 percent of total primary energy supply. The main forms of biomass are wood and charcoal, which are mainly used as household fuel for cooking and heating.

84.5 percent of rural households use firewood for cooking, followed by charcoal at 13.2 percent of households. In urban areas, most households use charcoal for cooking at 59.1 percent, followed by electricity (34.5%), while LPG use is currently minimal (0.1%). Other ATFs, such as ICS, have less than 1% penetration in both urban and rural households. Numerous issues have impacted Zambia's ATF sector in recent years including (i) droughts causing low energy production and load shedding, driving up energy tariffs and pushing consumers back to charcoal, and (ii) severe currency depreciation (between January and August 2020, the Kwacha depreciated 30% against the USD) driving up costs for major cleaner cookstove players importing improved technologies and reducing consumer purchasing power.

Building from a series of initial private sector focus group discussions the Alternatives to Charcoal project has undertaken a Market Analyses with the aim of providing market information, data, and analytics which can be used to overcome barriers to ATF expansion. This market analysis includes both desk and field-based research and focuses on LPG, electricity, biomass, and ethanol. The analysis also draws on lessons from markets in other countries that represent potential for uptake in Zambia (e.g. bio-ethanol fuel market systems in urban Kenya and PAYG LPG in Tanzania).

3. METHODOLOGY

This Market Analysis has been structured around the Market Systems Assessment Framework developed by Practical Action and informed by the Consumer Preference Study and Regulatory Review undertaken by the USAID Alternatives to Charcoal project.

The Market Systems Assessment Framework, developed by Practical Action, provides a common framework for systematically analyzing a range of existing, and potentially future, energy market systems. The framework is designed to help decision makers to increase their understanding of all critical components of each energy market system, identify the main obstacles and drivers that exist within each system, and help design critical interventions required to support the market; there are two stages, as follows:

Stage 1: Energy Market System Mapping - Stage one requires mapping each energy market against a defined framework, including the three levels of the market system (value chain; inputs, services and finance; enabling environment) to ensure all actors are identified, as well as their roles and how they interact with each other.

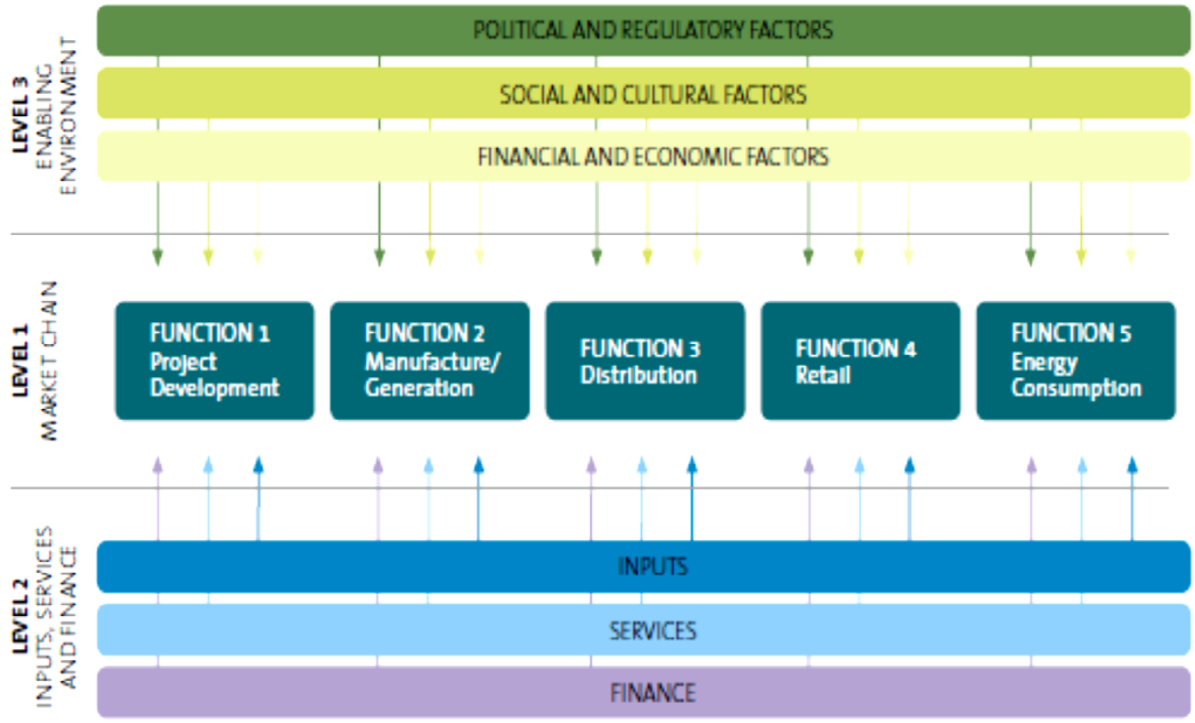


Figure 1 Market Systems Assessment Framework (Practical Action)

Stage 2: Identification and analysis of supporting interventions – This stage starts with the identification of all the main obstacles and potential opportunities that exist within the system, across all three levels. Once these have been identified, potential supporting interventions can be designed to try to overcome each barrier, as well as categorization and prioritization. Usually, interventions can be categorized as falling under either Technical Assistance (TA), or Financial Assistance (FA). **It is unlikely that one project can overcome all barriers in the market system, however, this stage helps identify all interventions that are likely to be critical in catalyzing the market.**

Identification	Market System Level Issue	Responsible Actor	Support Intervention	Category
Level 3 – Enabling Environment				
E1	**Lack of Rural Electrification Agency and Government Authorities to Support Mini-Grid Deployment** An institutional structure to oversee and enable the large scale deployment of mini-grids, including a rural electrification agency and a regulatory agency, is essential. Clearly defined roles and responsibilities as well as coordination between the various institutions that support rural electrification are required. Mini-grids should be given resources proportionate to their expected contribution to achieving universal access to electricity.	Ministry of Energy, Rural Electrification Agency, National Energy Regulator	Technical assistance to establish the structure, procedures, incentives, priorities and technical capabilities of government agencies.	TA_P

Figure 2 Market System Assessment - Enabling Environment

Information in this Market Assessment relating to the value chain was primarily collected through interviews with ATF actors. A2C interviewed stakeholders, including companies, industry associations and investors. Information relating to level 3 was informed by interviews with regulators and policy makers, as well as a standalone policy and regulatory review undertaken by A2C. While the A2C Consumer Preference Survey, conducted on 425 households in Lusaka, provided additional data on the practices and aspirations of consumers across three distinct income segments (high, medium, low). In all three levels supplemental information was sourced from literature, including Government reports and statistics.

4. LPG MARKET

4.1 LPG MARKET SYSTEM

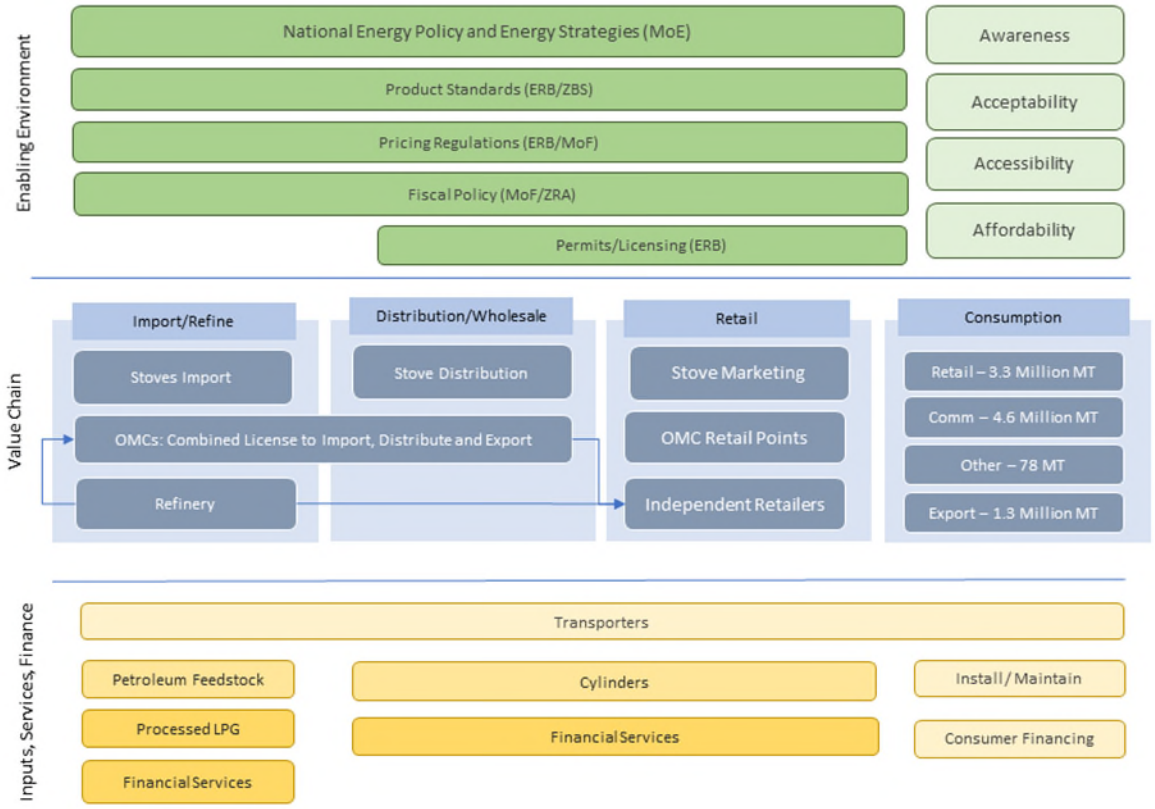


Figure 3 LPG Market System

VALUE CHAIN

Zambia's LPG value chain can be divided into the following stages: upstream oil and gas extraction, domestic LPG production at Indeni Oil Refinery and LPG importation, wholesale distribution, domestic retail, and exports. The domestic LPG market structure in Zambia is concentrated, characterized by a large market share owned by select few firms. The high cost of capital to set up an LPG business, as well as technological and regulatory barriers result in Zambia's concentrated domestic LPG market. As such, the LPG market in Zambia is dominated by a small number of OMCs, in fact, the top 5 companies hold 70% of the total market share as illustrated in Figure 5. However, it is clear from figures 6 and 7 that different OMCs focus on different elements of the market. While Afrox is the overall market leader, it does not feature in the top 5 companies in the retail market, focusing instead on the commercial market where it holds a 64% share. The retail market, which includes residential users, is primarily served by: Mount Meru, Ogaz, Exclusive Brands Africa, Chingases and Oryx. In 2020 (figure 4), the commercial market held the largest share overall, with 6,634 tons sold, followed by the retail market (3,311 tons) and the export market (1,339 tons).

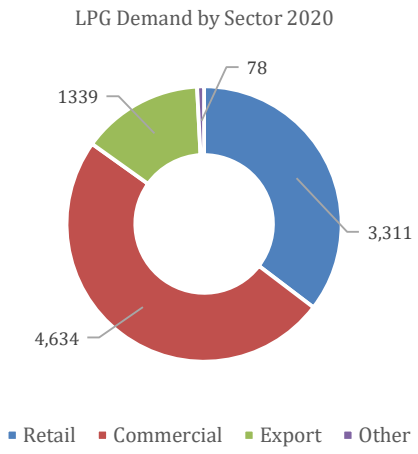


Figure 4 LPG Demand by Sector

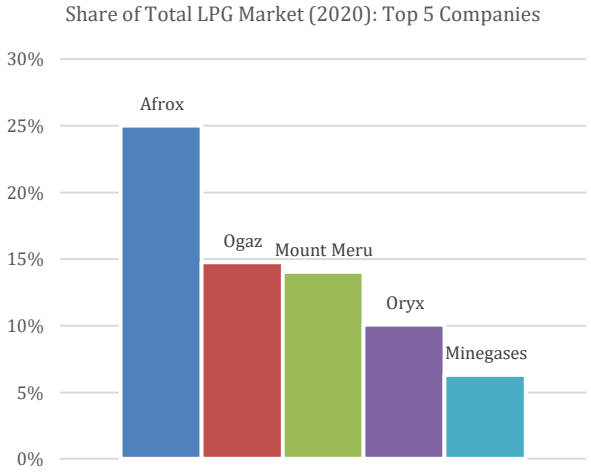


Figure 5 LPG Market Share: Top 5 Companies

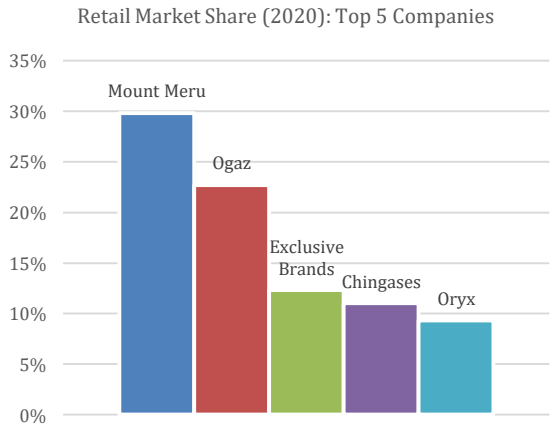


Figure 6 LPG Retail Market Share: Top 5 Companies

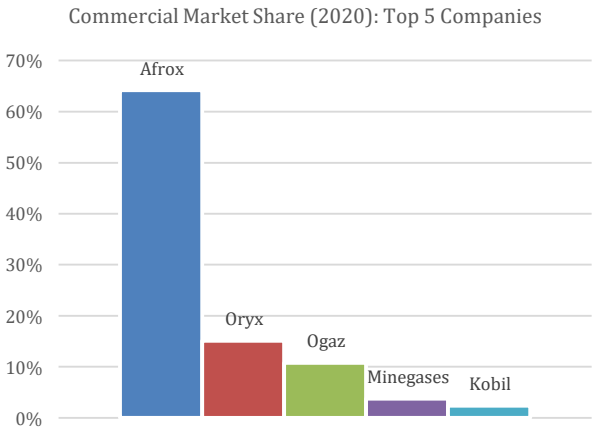


Figure 7 LPG Commercial Market Share: Top 5 Companies

Between 2017 and 2018, several LPG businesses self-organized to establish the LPG Association of Zambia. The association advocated for a more favorable business environment across the LPG value chain and provided oversight on the market price of LPG. However, the LPG association has failed to meet its intended coordination and regulation of the industry and has consequently become inactive. The respondents in our survey expressed a need for an active LPG association for better monitoring and regulation of the LPG value chain.

Refine and Import

Two critical pieces of infrastructure at the start of the LPG value chain are ageing: the Tazama pipeline transporting petroleum feedstock for Zambia's sole oil refinery and Indeni Oil Refinery. Tazama pipeline has a maximum capacity of 1.1 million tons per year but is currently operating at approximately 800,000 tons. While Indeni refinery has a maximum capacity of 1.1 million tons per year but is only capable of operating at 700,000 tons. The combined storage infrastructure for LPG at Indeni is 1800m^3. The refinery produces both LPG (60% propane and 40% butane) and Commercial Butane (40% propane and 60% butane). All the LPG is reserved for the national market, while commercial butane is exported due to claims from OMCs that it does not vaporize well under local climatic conditions. However, ERB believes this claim is not supported by appropriate scientific research.

At the time of writing, INDENI had been offline for nine months (December 2020 – August 2021) due to halted maintenance efforts caused by financial constraints, as well as insufficient supply of petroleum feedstock. But as of September 2021, production of LPG had recommenced. This presents operational challenges to maintain production and financial challenges to raise capital for upgrade plans. INDENI are exploring options to diversify their offering by decanting LPG into cylinders (as opposed to tankers) and selling directly to the retail market. To achieve this, they need to upgrade their plant to allow for direct bottling of LPG. In addition, INDENI aspires to purchase crude oil directly from the market, reducing their reliance on the Ministry of Energy who currently source 100% of the crude that is processed at the refinery.

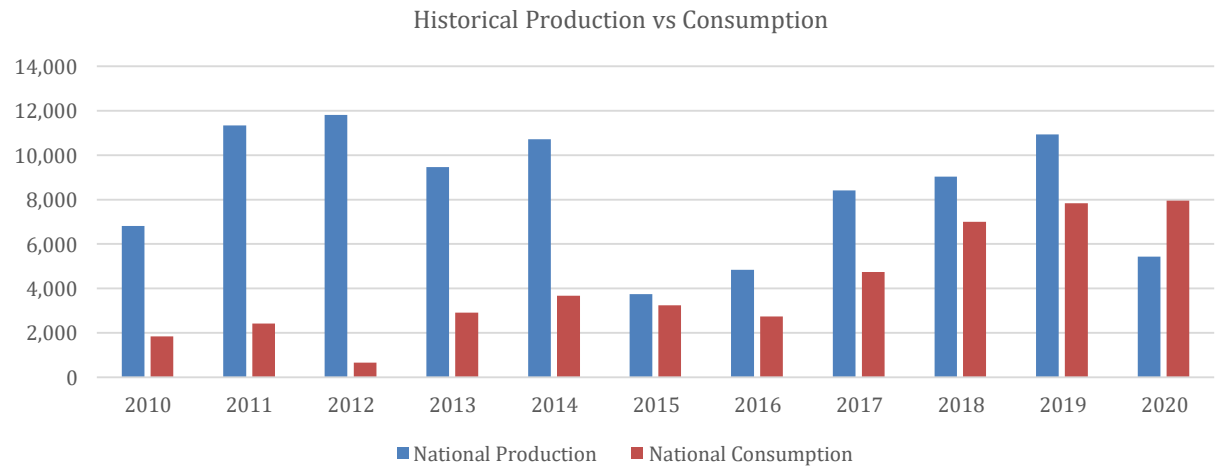


Figure 8 Historical Trends in LPG Production and Consumption

Due to these operational challenges, LPG production has fluctuated over the last 10 years (figure 8) from a low of 3,740 tons (2015) to a high of 11,809 tons (2012). During this 10-year period domestic consumption (excluding exports) has steadily increased to a high of 7,945 tons in 2020. In every year, apart from 2020, domestic production of LPG has exceeded consumption. However, in 2020 domestic production of 5,462 tons was insufficient to meet the national demand of 7,945 tons leading to increased imports to fill the gap. This has meant Zambia has been 100% dependent on imports of LPG since December 2020, which has increased the price due the higher transport costs associated with importing finished product. Typically, imports originate from South Africa, Mozambique, and Tanzania, mainly via road transportation with importation undertaken by Oil Marketing Companies (OMCs) who are issued a combined license that allows them to import, distribute and export LPG.

Distribute and Wholesale (OMCs)

OMCs such as Oryx Energies and Exclusive Brands Africa (EBA), with full ERB licenses, are authorized to import, distribute, export, as well as retail LPG in Zambia; they are also authorized to purchase LPG directly from INDENI Refinery. OMCs we interviewed indicated that LPG imports are largely through the Tanzanian border. Transportation is undertaken in bulk tankers from Dar Es Salaam port to depots in Zambia. In total OMCs in Zambia have a total storage capacity of 718 tons with Afrox, Oryx and Mount Meru holding the largest storage capacity (figure 9). The gas is then packaged in 48Kg cylinders and distributed to resellers, including Kiosks.

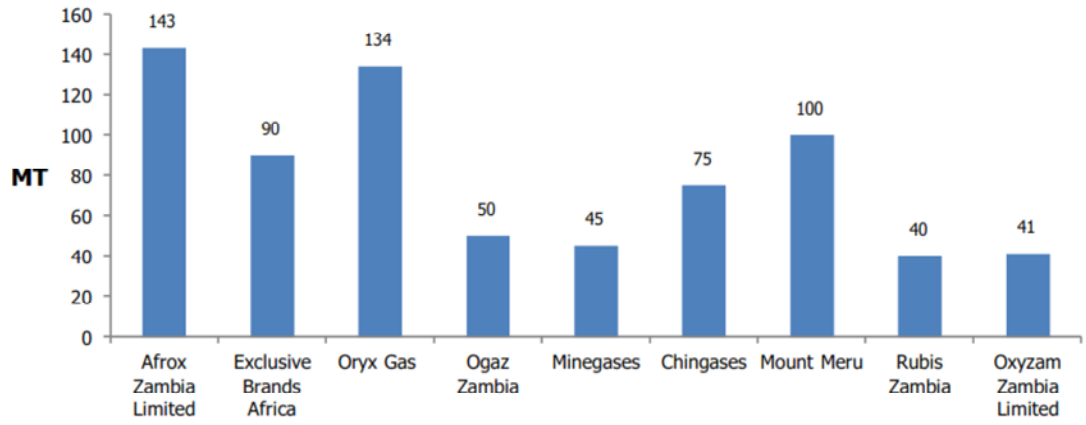


Figure 9 LPG Bulk Storage Facilities and Capacity

The period from December 2020 to August 2021, which saw INDENI shutdown, has drastically impacted OMC businesses due to the high costs of transporting imported LPG, which are then transferred to the end user. Consequently, the price increase has created challenges in attracting low-and-middle-income earners, and ultimately, led to a number of customers moving away from LPG as a cooking solution.

Exclusive Brands Africa (EBA) – CADAC has a footprint in Southern Africa and specializes in the warehousing and distribution of clean and renewable energy products. Its primary focus is the supply of LPG Gas products, and it is the Exclusive Licensee for the CADAC brand. EBA has bulk storage facilities for LPG exceeding 90 tons and has a strong network of LPG refilling stations which bring LPG to the people who need it most. Exclusive Brands Africa was originally established in Zimbabwe (2009) before moving to Lusaka (2021). EBA currently has a chain of 12 LPG KIOSK agents.

Oryx Gas Zambia Limited: Oryx Energies is a provider of energy solutions in Zambia, leveraging over 30 years of experience in sub-Saharan Africa. It has been operational in Zambia since 2007. The company currently has an employee roster of 217 staff and has physical presence in Lusaka, Ndola, Kitwe, Chingola, Solwezi, Kalulushi, Luanshya, Mazabuka, Livingstone, Chipata, Nyimba, Petauke, and Mumbwa. Oryx has at least 23,700 cylinders in distribution, with LPG storage capacity of 134 MT and 17 service stations acting as retail points.

Generally, OMCs operate a cylinder scheme which requires customers to pay a deposit toward a specific size of cylinder; a cylinder loan form is provided once a customer pays the deposit. The deposit is refundable upon presenting the proof of payment (cylinder loan form), less 10% for cylinder maintenance per year. Further to this, customers can only refill their cylinder at a depot of the owning OMC, or exchange it at an OMC branded retail location. Figure 7 below presents an illustration of cylinder deposit costs for several the main OMCs in Zambia. Typically, OMCs stock cylinder sizes of 6, 9 and 19 Kgs, except for Mount Meru which stocks 6, 15, 38 and 48 Kg sizes and CADAC which sells 3, 5, 7, and 9 Kgs cylinder sizes. All suppliers, except CADAC, operate a deposit mechanism for cylinders. The lowest cost entry point is a 9Kg cylinder from Afrox, requiring a deposit of ZMW 300, which is cheaper than a 6Kg cylinder from Oryx (ZMW 450). At the time of writing, it appeared that three OMCs were experiencing challenges with cylinder stock. Reports regarding two companies indicated that they had exhausted reserves of cylinders and were unable to sign-up new customers. While the third company appeared to have a significant number of customers who were no longer using LPG, but had retained their cylinder, reducing the available pool for new customers.

OMCs typically engage resellers to retail LPG to end users. To become an authorized reseller for LPG, retailers must meet some basic criteria: (1) be an established Zambian Company; (2) demonstrate financial capacity to pay for cylinder deposits; (3) have secure premises for business operations; (4) demonstrated history of running a business; (5) have all necessary registration, licensing, and certifications (see figures 10 and 11).

Table 1: LPG Cylinder Deposit Costs

Product	Afrox	Oryx	CADAC	Ogaz	Mount Meru
3Kg Cylinder			ZMW 865 Purchase		
5kg Cylinder			ZMW 1,025 Purchase		
6Kg Cylinder	ZMW 800 Purchase	ZMW 450 Deposit		ZMW 500 Deposit	ZMW 600 Deposit
7Kg Cylinder			ZMW 1,180 Purchase		
9Kg Cylinder	ZMW 300 Deposit	ZMW 700 Deposit	ZMW 1,280 Purchase	No Stock	
15Kg Cylinder					ZMW 800 Deposit
19Kg Cylinder	ZMW 300 Deposit	ZMW 1000 Deposit		No Stock	
38Kg Cylinder					ZMW 1500 Deposit
48Kg Cylinder					ZMW 2000 Deposit

Retail

There are four primary retail channels for LPG in Zambia, which include physical premises, petrol stations, kiosks/containers and home delivery. In practice, many retailers are implementing a number of these at the same time. For example, Afrox supports 12 kiosks, 19 physical premises and 2 free-lance mobile distributors. While CADAC has established a network of 12 refiling and cylinder exchange kiosks. In total there are 333 petrol stations in Zambia, with 118 of those located in Lusaka, however, we were unable to ascertain how many of these currently stock LPG.

Many smaller LPG retailers operate under a kiosk model. Through this model an entrepreneur can apply to become an LPG distributor through an OMC who is already licensed by the Energy Regulation Board (ERB). The kiosk model lends itself to an entrepreneur seeking to invest in the LPG business who does not have the required finances to set up a fully independent business. Further, the business model does not require ERB licensing, making market entry more flexible, but also means that the kiosk owner relies solely on availability of LPG from the OMC they are

Sustantivo Limited is a Zambian-owned start-up company using the kiosk LPG distribution model. The kiosk outlet is situated in Ndola's light industrial area and is contracted under the AFROX license. The business was established in February of 2020 when its owner saw a gap in the market access to LPG in small quantities. Based on a market survey, the owner targeted a strategic location where truckers and households could easily buy LPG in small quantities. The business has 1 kiosk, with plans for expansion into more locations. The LPG kiosk business currently employs 4 people and has an annual estimated revenue of approximately ZMW 921,600.00.

Awrich General Supply Limited (WEGAS) commenced its operations starting November 2019. It is a growing business with presence in Lusaka and Chilanga districts, Lusaka province. As most consumers don't have their own transport, WEGAS offers an innovative home delivery service. The inspiration to start WEGAS came from the need for an alternative solution to cooking fuel due to the erratic electricity supply from ZESCO.

contracted to. However, kiosk operators are free to distribute for a number of different OMCs, as long as they separate stock into dedicated OMC specific cages. This is a fast-growing model on the Zambian market and has the potential to make LPG accessible to more households in urban Zambia.

As the kiosk operators buy LPG from OMCs, they are not burdened with bottling plant setup costs, which are the responsibility of the OMC. In addition, the cylinders are the property of the OMC. Consequently, kiosk businesses are constrained by the performance and operations of the OMCs they are contracted to. Some kiosks are equipped with a small, specialized pump to decant LPG from larger (48Kg) cylinders into smaller household cylinder sizes. This is an attractive proposition for customers who have the option to purchase LPG at the per kg price and based on their need.

Typically, LPG storage facilities under the kiosk model are limited to 20-foot containers in which the kiosks are setup. This limits the quantity of LPG stored for a particular period. Transportation of LPG is undertaken either by the OMCs or collected from the OMC bottling facility by the kiosk operator, using their own light trucks. The kiosk cylinder ownership model replicates the existing cylinder scheme implemented by OMCs throughout the market. Under this scheme cylinders are not sold to the customer, instead they are rented out at a refundable fee, at a mark down of 10 per cent per year of use. Customers also have an option to purchase cylinders from reputable sellers. However, it is common practice to only refill gas for the branded cylinder of the OMC. In response, retailers are looking to engage distributors so that they can stock multiple brands at one location.

Requirements to become a Kiosk Agent:

1. Capital of K150,000 to K200,000
   a. Container: K50,000
   b. Cylinder deposit: K50,000
   c. LPG: K50,000
2. Fully registered company
3. Company Tax-Payer Identification Number
4. Council Certificate
5. Fire Certificate

LPG kiosk sales are made through two main ways. The first is the exchange of an empty cylinder with a full cylinder of same size and brand. The second method is sale of LPG per kg, however, this is limited to amounts between1kg to 10kg due to the size of the specialized pumps needed to decant LPG gas from larger 48kg containers. For LPG sold per kg, the sale is dependent on the state/condition of each container and the compatibility of the nozzle.

Typically, retail kiosk operators target LPG at low- and middle-income households as these consumers are most likely to be faced with logistical challenges in transporting LPG. Similarly, kiosks are offering more flexible modes of payments to make LPG more affordable and accessible, with mobile money payments becoming common. Others have structured sales of LPG gas and appliances through credit sales. Gas Connect indicated that it offers two forms of credit facility; 7-day credit facility for new clients on both the stove and the gas, while a 30-day credit facility is available to returning clients. Gas Connect is also structuring a lay-by facility of up to 3 months with zero interest. Interest is only added to sales of LPG technology on higher purchase agreement. Higher purchase is provided as a complete installation package which comprises of the technology (stove), cylinder, gas, connectors, and installation. Initial payment of 60% is required and balance paid within 60 days plus interest.

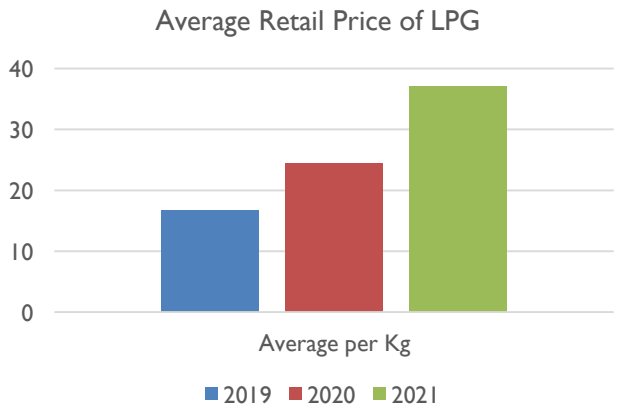


Figure 10 Average LPG Prices per Kg

Partly in response to Covid 19, some entrepreneurs, like WeGas and Ogaz, have invested in an LPG delivery and installation service. There is growing potential for this sales model which needs to be explored, its viability

and practically assessed, with profitability being a key factor to be determined. However, innovations such as home delivery appear to have positive impacts on making LPG more accessible and increasing adoption. But many smaller operators are constrained by access to finance, meaning they struggle to invest in vehicles and marketing to scale their businesses.

As indicated earlier, the price of LPG has significantly increased over the last 2-3 years. In 2019 a kilogram of LPG was retailing for ZMW 17 on average, which increased to ZMW 24 in 2020 and further still to ZMW 36 in 2021 (figure 10). This price increase has been driven by two factors. Firstly, the Zambian Kwacha has weakened as compared to the US dollar. At the start of 2019 ZMW 11 was equivalent to 1 USD, however, by July 2021 the rate had shifted to ZMW 22 to 1 USD. Secondly, towards the end of 2020, INDENI Refinery went offline due to unavailability of petroleum feedstock and maintenance issues, this forced OMCs to import greater amounts of finished LPG from outside Zambia, with increased transport and transaction costs. Effectively, during this three-year period, the price of LPG has doubled.

In terms of appliances, retailers offer a range of products at varying price points (table 2). At the entry level the single burner which attaches directly to the top of the cylinder retails at ZMW 235. Two burner stoves can be bought for as little as ZMW 395, but typically cost around ZMW 700. While larger four burners with oven start from around ZMW 3950 for an electric-LPG combo.

Table 2: LPG Appliance Costs

Product		Radian	Game	Shop Rite
Single Burner on Cylinder		Brand: CADAC EAZI Gas Price: ZMW 235		Brand: CADAC Price: ZMW 270
Two Burner Cooker		Brand: CADAC LP 2 Price: ZMW 770		Brand: LK Price: ZMW 700
		Brand: Zeera Steel Price: ZMW 395		
Four Burner with Oven		Brand: Defy Price: ZMW 4,450	Defy ZMW 5,723	
Combination gas and electric, with oven		Brand: Superior Price: ZMW 3,950	Defy ZMW 6,372	

Consumers

In 2020, the commercial sector accounted for 49% of LPG demand, followed by retail (35%), export (14%) and other (1%). According to ERB (2019) 3.5% of households in Lusaka use LPG at least some of the time, equating to 20,683 households (2015 population figures). However, according to the A2C Consumer Preference Study, all households practice fuel stacking, with electricity and charcoal featuring most prominently and only 4% of high-income households (5,334 households) reporting LPG as their main cooking fuel.

While adoption is minimal, knowledge of LPG fuel is reasonably high across all income groups, with 46%, 68% and 99% of low, medium and high-income households respectively aware of the fuel. But awareness of LPG, as a fuel, does not carry through to LPG appliances, with only 27% of low-income households knowing about LPG cylinder burners. After electricity, LPG is the second most aspirational fuel with 16%, 26% and 36% of low, medium and high-income households respectively indicating it as their preferred choice as it cooks faster, is clean and doesn't create any smoke; the desire to use LPG was slightly higher amongst men. The primary consumer dislikes regarding LPG were safety and difficulty transporting the cylinders.

ERB (2019) found that on average low-income households spent ZMW 36 per month on LPG, while medium and high-income households spent ZMW145 and ZMW 302 respectively. Similarly, the A2C Consumer Preference Study (2021) estimated that medium income households spent ZMW 175 and high-income households spent ZMW 350 on average each month; the A2C study did not identify any low-income households using LPG. Based on data collected for this market assessment the lowest cost for a household to switch to LPG comes in at ZMW 841 ($51) based on a CADAC cylinder top burner (ZMW 235), a 9Kg cylinder from Afrox (ZMW 300) and gas at ZMW 34 per Kg (Afrox).

INPUTS, SERVICES AND FINANCE

Petroleum Feedstock and LPG: The LPG sector in Zambia is clearly reliant on the importation of petroleum feedstock and/or finished LPG product. The risks of substantial future cost increases are high for LPG based on world market price projections for petroleum and LPG, potential domestic currency depreciation, and possible removal or reduction of subsidies in Zambia (CEADIR). At the time of writing INDENI had been experiencing shortages of petroleum feedstock, forcing the refinery to cease production of petroleum products, and forcing OMCs to import LPG.

Cylinders: One of the key inputs into the LPG value chain are cylinders which are sold in sizes ranging from 1.4 kgs to 48 kgs. LPG cylinders used for domestic purposes are sold using two types of cylinder ownership schemes, namely; Company Owned and Customer Owned:

- Company Owned: Cylinders are owned by the company and leased or loaned to the customer. Customers exchange empty cylinders for a full one and pays for the LPG. The company is responsible for filling and supplying safely maintained cylinders and it is common to have the owner's investment secured through a system of refundable deposits or guarantees in cash.
- Customer Owned consists of two modalities:
    a. *Centralized cylinder filling and distribution system*: Customers exchanges legally owned cylinders for the same types. LPG dealers are responsible for maintenance and replacement of cylinders.
    b. *Bulk distribution/mini-filling plant system*: Customers own personally identified cylinders and bring them to local filling plants for replenishment. Customers are responsible for any maintenance and replacement of cylinders, however mini-plant operators play a vital role in maintaining the safety in this system by inspecting cylinders and reject those that do not meet safety standards. Cylinders that fail to meet safety standards must be disposed and be replaced. The filling plant is responsible for the disposal or recycling of end-of-life cylinders.

However, in practice, the main form of cylinder ownership scheme in Zambia is Company Owned, with the main OMCs locking customers into exchanging or filling cylinders at their retail outlets only. This creates challenges for consumers who must search out brand specific locations. The introduction of an industry wide cylinder exchange pool would help to make LPG more accessible to consumers by increasing the number of locations open to them. Furthermore, the depreciation of the Zambian Kwacha has created challenges for OMCs looking to import additional stock of cylinders, with some OMCs no longer able to take on new customers due to cylinder shortages. However, in recent months the kwacha has strengthened which may encourage OMCs to import additional cylinders.

Installation/Maintenance Technicians: All companies indicated a shortage of skilled labor, requiring them to implement their own training and certification system for installers. Consequently, many skilled personnel working in the LPG sector are either current or former employees of LPG distribution companies. The quality and extent of training varies from company-to-company, potentially impacting consumer safety and confidence. A standardized technical training syllabus would help to ensure enough skilled labor is available on the market that are certified to the highest possible level.

Financing and Investment Needs: The majority of OMC's are group companies. As such, most of the investment originates from within the group and its shareholders. Thereafter, expansion of operations is through reinvestment of profits and commercial loans. Of all the ATF providers in Zambia, OMCs are the most likely to be able to access debt financing from the commercial banking sector. However, funding is often a constraint, particularly for the acquisition of additional tankers; setting up more retail points; acquiring of LPG monitoring systems; and research and development.

Due to the difficulty in accessing financial support or investment for small scale businesses, the source of financing for kiosks is often through personal finances or diverting profits from another business. As such, the need for financing cannot be over emphasized. Investment needs center on expanding the number of kiosks the businesses ran. More specifically, financing is needed for the initial set-up costs, 20ft container, dispensing pumps, transportation vehicles, back-up energy systems, LPG cylinders and gas.

At the consumer level, financing is needed to reduce the upfront cost barrier of acquiring a full LPG kit (stove, cylinder, gas and accessories) as this is often beyond the ability-and-willingness to pay of low-to-middle-income households. Innovative financing options are required that either draw on technological advances, such as PAYG LPG, or through strategic partnerships such as salary deduction schemes and collaborations with MFIs, or through more traditional approaches such as layby schemes.

ENABLING ENVIRONMENT

The Energy Regulation Board (ERB) is the lead entity involved in reviewing and issuing licenses for energy businesses, including those providing ATFs such LPG. According to the Energy Regulation Act Cap 436, ERB oversees the following functions (Energy Regulation Board, n.d.):

- Issue licenses
- Monitor performance of licensed organizations' activities, as well as competition
- Receive and investigate compliance from customers of licensed organizations
- Work with the Zambia Bureau of Standards to design standards that govern quality, safety and reliability of supply of energy and fuels

ERB operates an online platform that provides checklists of requirements needed to receive a license, tailored to biofuels, biogas, coal, LPG, refined petroleum. Once an organization submits a completed application form, it is required to a pay a non-refundable application fee of approximately 0.1% of the envisaged project cost. This is followed by a physical inspection by ERB, public advertisement and comment intake on the tentative license, and finally, issuing the license (Energy Regulation Board, n.d.).

In terms of LPG, the ERB currently regulates production, storage, distribution, transportation, and retail under the existing licensing regime for petroleum products. This has posed a challenge as the existing licenses do not adequately address the specific technical requirements associated with LPG. To take part in the LPG market, entities must hold the appropriate licenses pertinent to their business activities (Energy Regulation Board, 2019); ERB issues the following license types:

- Combined license that covers distribution, importation and export of LPG
- Export LPG
- Retail LPG

Under the combined license, OMCs can engage in the distribution (of LPG among other petroleum products), without a specific requirement for dedicated LPG storage. The following table sets out the business registration, certificates and licenses required by OMCs who want to import, distribute, retail and export LPG.

Table 3: Combined License Requirements for OMCs

OMC Business Registration, Certifications, and Licensing		
Name of Certificate	**Issuing body**	**Cost (ZMW)**
Company Registration	Patents and Company Registration Authority (PACRA)	Dependent on company size and ownership type
Tax-Payer Identification Number (TPIN)	Zambia Revenue Authority (ZRA)	Free
Trading Certificate – Renewable yearly	Local Council	ZMW 2,000
Fire Certificate – Renewable half yearly	Local Fire Brigade	ZMW 700
License to Import, Export, Distribute	Energy Regulation Body (ERB)	Application Fee: ZMW 1,000.20 Processing Fee: 0.1% of investment Annual fee: 0.7% of gross turnover
Retail of petroleum products	Energy Regulation Body (ERB)	Application Fee: ZMW 1,000.20 Processing Fee: 0.1% of investment Annual fee: 0.7% of gross turnover
Inclusion license (per kiosk, renewable every 5 years)	Energy Regulation Body (ERB)	ZMW 2,000
Environmental Impact Assessment clearance	Zambia Environmental Management Authority (ZEMA)	20,000 – 35,000

Currently, for kiosk businesses, there is no requirement to hold any ERB license unless the business expands into bulk supply. This is because business operations fall under the umbrella of at least one commercial player with a valid ERB license. But, for trading purposes, the table below sets out the key certificates and registrations each kiosk must hold.

Table 4: Certificates and Registration Required by OMC Distributors

Kiosk Business Registration and Certificates		
Name of Certificate	**Issuing body**	**Cost (ZMW)**
Certificate of Incorporation	Patents and Company Registration Authority (PACRA)	Dependent on company size and ownership type
Tax-Payer Identification Number (TPIN) Certificate	Zambia Revenue Authority (ZRA)	Free (No Cost)

Trading Certificate – Renewable yearly	Local Council	2000
Fire Certificate – Renewable Half yearly	Local Fire Brigade	700

In Zambia, the regulation of pricing depends on whether the LPG is sourced from INDENI or imported from outside the country. The wholesale price of LPG from INDENI is set by ERB using a cost-plus model, while the export prices are set by TAZAMA, and retail prices are set by the retailers. For imported LPG the retail price is determined by the trader or importer, depending on negotiations with the supplier. As of 2019, the cost elements in the wholesale price build are described in table 5.

Table 5: Post-plus LPG Wholesale Pricing Model

Cost Element	Unit Cost	Basis
Cost of petroleum feedstock (*Cost-Insurance-Freight at Dar-es-salaam*)	Market Rates	Contract/Supplier Invoice
Ocean loss at 0.3%	0.30%	Best Practice
Wharfage at 1.25%	1.25%	Tanzanian Harbour Authority
Finance Charges	4.00%	Financier
Collateral Manager	US$0.39/mt	Stock Monitoring Agreement
Insurance	0.15%	Insurer
TAZAMA Storage fee	US$2/mt	TAZAMA
TAZAMA Pumping fee	US$54.00/mt	Approved ERB Pumping Tariff
TAZAMA Pipeline losses *(pipeline consumption of 0.83% & allowable pumping losses of 0.65%)*	1.48%	Determined by ERB
Agency fee	US$5.00/mt	Agency Agreement
Refinery fee	US$60.38/mt	Approved ERB Processing Fee
Refinery Processing Losses	9%	Determined by ERB
Terminal Losses (1% for LPG, 0.5% for Petrol Kerosene & Jet A-1, 0.3% for diesel & HFO)	1%, 0.5%, 0.3%	Best Practice

In 2016, ERB introduced a light-handed regulation for pricing of LPG, which allows sellers to set retail prices but authorizes ERB to review cost build ups for reasonableness. To do this, OMCs submit their detailed proposed retail price adjustment to ERB for scrutiny, supplemented with information related to the pricing of LPG, such as price build-ups, commercial invoices of procured LPG, and other information deemed necessary. LPG exports, cooking appliances and imports are not subject to taxes, however, cylinders are subject to 15% import duty and 16% VAT (table 6). The contribution of taxes collected from LPG to the country's total tax overturn has been reported to be between 0.02-0.05% between 2014-2018. In order to promote LPG use, the Government of Zambia established a tax emption for LPG and associated products imported from other countries in the Southern African Development Community (SADC) (Energy Regulation Board, 2019).

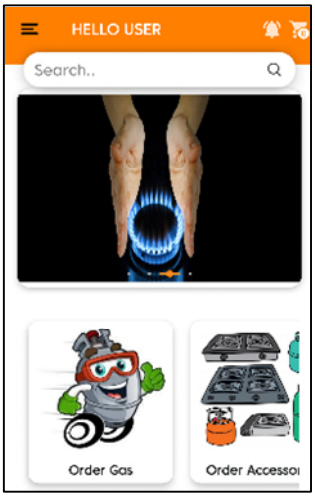
Table 6: VAT and Duty Status for LPG

Item	HS code	Import Duty	VAT	Excise Duty
Containers for compressed or liquefied gas	73110000	15%	16%	N/A
Cooking appliances and other appliances that use gas	73211100 (gas fuel)	0%	0%	N/A
Petroleum Gases and gaseous hydrocarbons, Liquidifed	27111900	0%	0%	N/A

4.2 EMERGING MARKET DEVELOPMENTS AND INNOVATIONS

PAYG LPG: Affordability is a major barrier to LPG adoption, particularly for lower income households. Pay-As-You-Go enabled cookstoves can provide consumers in last-mile markets affordable options to access clean cooking technologies.[1] For example, Paygo Energy in Kenya have developed a smart meter for LPG which allows households to pay for gas by the gram. Making payments in this way more closely replicates practices in the charcoal sector, as well as allows LPG companies to spread the cost of the cooking appliance over time, reducing the upfront cost barrier to households. Paygo Energy licenses its software and hardware to other players in the LPG industry who want to introduce a more flexible consumer financing approach. It also allows LPG businesses to better manage their inventory and provide an enhanced customer service experience, as they can monitor usage and deploy LPG deliveries as households run low on gas.

Home Delivery: Alongside affordability, accessibility is significantly hindering LPG uptake, even in higher income households. Companies in Zambia are beginning to address this barrier by introducing home delivery services for LPG. However, many of these smaller distributors and retailers are financially constrained and cannot invest in the required transportation and marketing to scale their offering. With adequate support, home delivery services, targeted at more wealthy LPG consumers, have the potential to lower the accessibility barrier, making LPG more convenient and resulting in increased uptake.



GasItApp, developed by Daniel Kabeleka, founder of KDD Gas, is a mobile application running on both android and IOS mobile devices. It allows customers to make orders for LPG and LPG related appliances and accessories and have the orders delivered to the customers' destination. Customers can request for a technician to come to their premises to do their gas installation and after service routine maintenance services. In addition to this, the app gives you a platform to call in for a consultant in case of an emergency. GasItApp allows you to see which point of sale is closest to you and allows you to call in directly from the app to check or inquire if the desired product is available. Ordinary (24 hours) and express (4 hours) delivery options are available to customers based on their needs. The app also allows the client to add their physical address via google maps to ensure easy and efficient location of the customer's delivery address by delivery personnel. GasItApp has a corresponding app called "delivery boy." Delivery boy is an internal app that will be installed on their delivery personnel mobile phones. This app is designed to make navigation and correspondence among their customer service center, delivery personnel and the customer easy and convenient. The app is currently available on the Google Play Store in prototype format for testing.

Cylinder Exchange: An LPG Cylinder Exchange system facilitates the exchange of cylinders amongst LPG marketing companies. The system is based on the concept that LPG cylinders are returnable containers and are owned by the brand owner. As such, the consumer pays a deposit on the initial acquisition of the cylinder. Once the interchange occurs, the brand owner of the filled cylinder is then tasked with handing over the empty

[1] https://www.angaza.com/2021/07/13/angaza-and-atec-expand-partnership-with-two-new-ecook-cooktops/?utm_source=linkedin&utm_medium=organic_social&utm_name=Angaza_ATEC

cylinder collected to the rightful brand owner within an agreed period. This system has been successfully implemented in Kenya. The rest of the EAC member countries (Uganda, Tanzania, Rwanda, and Burundi) are in the process of adopting the LPG cylinder exchange systems to enhance the usage of LPG in East Africa. Introducing a cylinder exchange pool increases flexibility for customers and promotes competition in the LPG sector, as consumers are free to seek out their closest exchange point, regardless of brand.

LPG Refills: CADAC Zambia is establishing a series of LPG refilling points for their branded cylinders, as well as cylinders that are privately owned by consumers. These refilling points provide flexibility in the amount of gas purchased. This approach could be expanded so that any brand of cylinder can be refilled, which would provide consumers with increased availability and flexibility when sourcing LPG. Introducing a large volume of low cost, unbranded cylinders to the Zambian market may help to encourage scale up of industry wide refiling points.

4.3 BARRIERS AND SUPPORTING INTERVENTIONS

Table 7: LPG Barriers and Supporting Interventions

Market System Issue	Support Intervention
Enabling Environment	
Awareness: Levels of awareness about LPG as a fuel are relatively high, but awareness about appliance types is low. This may be a barrier to households as they do not understand how LPG can meet their cooking needs.	Technical Assistance: A2C can partner with the LPG sector and appliance retailers to promote LPG and appliances more effectively through its SBCC and communications strategies.
Accessibility: There are currently not enough retail points and knowledge about where to refill/exchange cylinders is low. Many potential customers don't have suitable transport to convey cylinders over longer distances.	Technical Assistance: Development of a national cylinder exchange pool model for adoption by ERB and LPG companies Technical Assistance: Support to smaller retailers to increase the number of retail points and assist them to identify the most suitable locations, with maximum market reach.
Acceptability: ERB, and the A2C Consumer Preference Study, found that safety is one of the main concerns related to LPG, with many people believing it to be dangerous.	Technical Assistance: Collaborate with ERB and LPG companies to increase awareness about LPG safety through the A2C SBCC campaign.
Affordability: Cooking with LPG is more expensive than electricity and likely more expensive than charcoal. In addition, the upfront cost of purchasing a full kit (stove, cylinder, gas and regulator) is a significant barrier to adoption by low- and middle-income households. This is, in part, because vat and duty still apply to LPG cylinders, increasing costs to the consumer. In addition, due to challenges at INDENI a significant amount of LPG is being imported, at a higher cost.	Technical Assistance: Conduct Cost Benefit analysis on the impact of removing taxes on cylinders and collaborate with GRZ to provide a tax holiday.
Value Chain	
Refinery: Currently all commercial propane is exported as it is not thought to perform well under local climatic conditions. This creates	Technical Assistance: Conduct study to determine performance of propane to understand performance under local climatic

potentially unnecessary supply constraints in the LPG market.	conditions, with the aim of increasing demand on the local market.
Refinery: INDENI refinery is operating at reduced capacity due to lack of maintenance and upgrades on the facility, meaning reduced throughput, resulting in lower volumes of LPG and increased unit costs.	Technical Assistance: Maintenance and repair of the refinery is beyond the scope of A2C, however A2C could collaborate with GRZ, INDENI and development partners to understand how reduced capacity impacts LPG prices. Furthermore, efforts can be made to advocate and lobby the GRZ to devote budgetary funds to perform maintenance on the refinery.
Industry Coordination: The LPG industry Association is not functioning, reducing coordination in the sector and lowering bargaining power.	Technical and Financial Assistance: Convene and support LPG companies to revive the association, allowing them to meet regularly and lobby for solutions to challenges they have identified.
Inputs, Services, Finance	
Pipeline: TAZAMA pipeline is operating at reduced capacity, resulting in lower volumes of petroleum feedstock and increased unit costs.	Technical Assistance: Maintenance and repair of the TAZAMA pipeline is beyond the scope of A2C, however A2C could collaborate with GRZ, INDENI and development partners to understand how reduced capacity impacts LPG prices. Furthermore, efforts can be made to advocate and lobby the GRZ to devote budgetary funds to maintain the pipeline.
Transport: Currently small retailers, operating home delivery services, do not have sufficient vehicle capacity to adequately serve the market, limiting "last-mile" distribution and limiting accessibility to households that do not have transport options.	Technical Assistance: Provide support, through communications campaigns, to home delivery businesses to raise public awareness about home delivery, provide technical assistance to develop the business case. Financial Assistance: Through the A2C grants program provide funding to home delivery businesses to increase their transport capacity.
Cylinders: Stock of cylinders is limited, partly due to existing fiscal policies, limiting the expansion of the sector. In particular, there is need for smaller cylinder sizes to make LPG more affordable to low- and middle-income households.	Financial Assistance: Through the A2C grant facility support LPG retailers to source additional stock of cylinders, ensuring a high representation of smaller sizes. Ideally cylinders would be brand neutral and refillable by any LPG retailer.
Consumer Finance: The high upfront cost of a complete LPG kit creates a significant barrier to adoption for low- and middle-income households. Innovative financing options would help to overcome this barrier and increase the potential market size for LPG.	Technical and Financial Assistance: Support the LPG sector to introduce PAYG LPG to Zambia by developing the business case (technical assistance) and reducing the capital costs required to launch the model (financial assistance). Technical Assistance: Collaborate with LPG retailers to develop workable consumer financing models through credit and lay-by.
Business Finance: Access to affordable finance is a barrier across the entire value chain. However, it is most acute for independent retailers, limiting their ability to scale up retail points and hampering accessibility.	Technical Assistance: Support retailers to improve their business models to position them as investment ready. Provide match making services between businesses and investors. Financial Assistance: Through the A2C grants facility, make funding available for retailers to scale the number of retail outlets.
Installation/Maintenance Technicians: There is a need to develop standardized training courses for LPG installers to increase safety standards.	Technical Assistance: In collaboration with ERB and TEVETA, develop a national curriculum for training installers of LPG facilities.

5. ELECTRICTY

5.1 ELECTRICITY MARKET SYSTEM

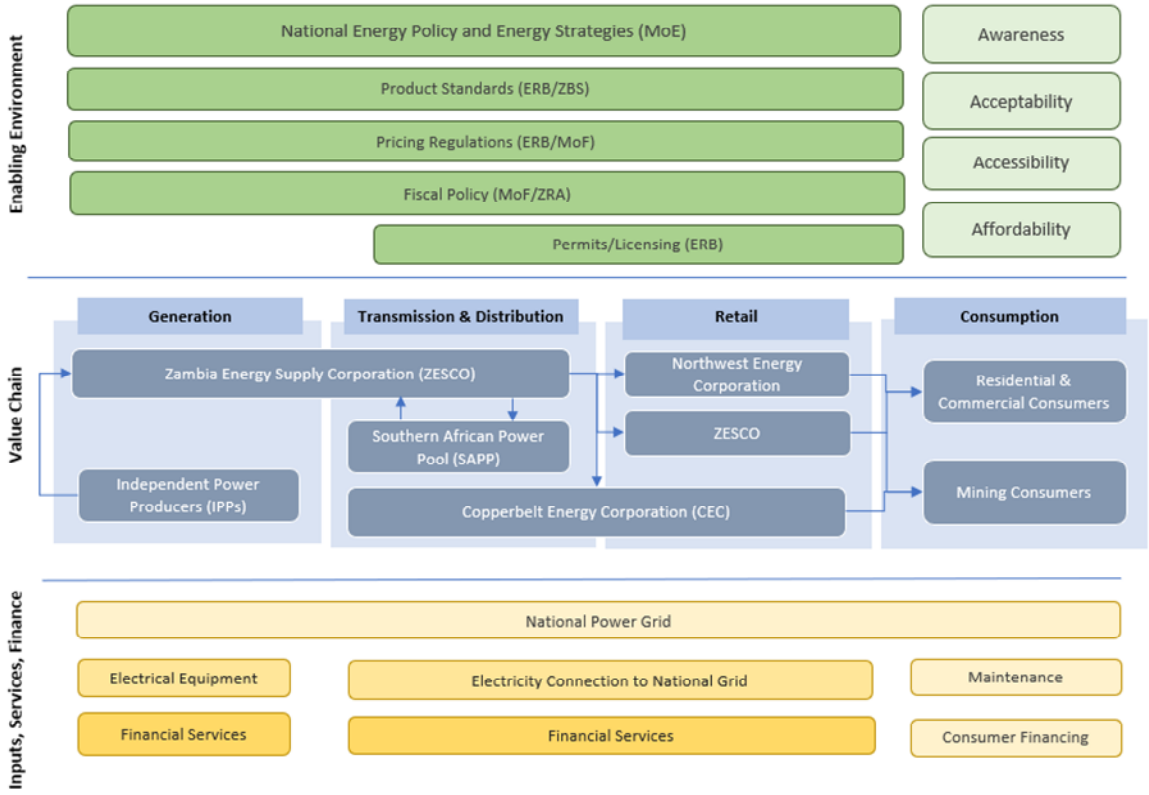


Figure 11 Electricity Market System

VALUE CHAIN

Zambia's electricity generation mix is dominated by hydro power which comprises over 95% of total generation capacity. About 90% of hydro generation comes from just two projects – Kariba North and Kafue Gorge, located in the country's Southern Province. With 40% of the water resources in the Southern African Development Community (SADC), Zambia has about 6,000 MW of unexploited hydropower potential, while only about 2,400 MW has been developed to date. The electricity sector operates under the single buyer model, with several large independent power producers, transmission, and distribution operators. The single buyer functions are assumed by the vertically integrated utility company, Zambia Electricity Supply Corporation (ZESCO), which also controls most of the generation, transmission, and distribution capacity in the country. ZESCO Limited is a parastatal company formed after the enactment of the Zambia Electricity Supply Act. Electric cooking appliances in Zambia are widespread and include a range of different technologies, providing several different services and covering numerous price points. Electric cooking is the most popular ATF in Zambia, driven by historically low electricity tariffs and high connection rates, particularly in urban areas. However, recent tariff increases, and significant load shedding have driven some households back to cooking with charcoal and have resulted in GRZ to prioritize alternatives, such as LPG, for cooking.

Generate and Import

Established in 1970, ZESCO currently owns eight hydropower stations with a combined installed capacity of 2,398 MW, thermal electricity plants to capacity of 330 MW, solar plants with capacity of 89 MW, diesel power plants with a combined capacity of 83 MW, and Heavy Fuel Oil with installed capacity of 110 MW, resulting in a total installed capacity of 3,011 MW (ERB Report, 2020). In 2020, total national generation reached 15,497 GWh. Of this, large hydro power stations owned by ZESCO (Kafue Gorge, Kariba North Bank, Kariba North Bank Extension, and Victoria Falls) produced 11,716 GWh, accounting for 76% of electricity generated. The remainder was generated from small and mini-hydro power plants (1%), diesel power plants (<1%), and independent power producers (23%); see Figure 12 below.

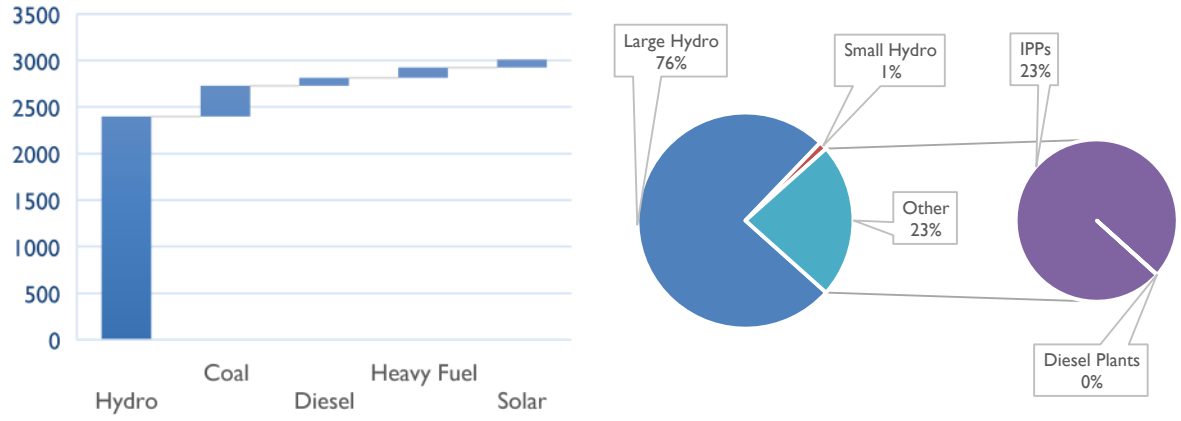


Figure 12 Installed Capacity by Energy Source

Over the last 5 years Zambia gas been experiencing significant and disruptive load shedding. As of 2020, the projected demand was 2,310 MW against an average generation of 1,500 MW. Consequently, the highest power deficit seen in the year was 810 MW and was attributed to reduced water levels in the main reservoirs for power generation. This power deficit was distributed across ZESCO's four divisions namely Lusaka, Copperbelt, Northern and Southern. During 2020, the daily load shed in Lusaka Division was an average of 213 MW while the Copperbelt Division shed a daily average of 120 MW. The Northern and Southern Divisions shed daily averages of 71 MW and 65 MW, respectively (ERB Report, 2020). The deficit during 2020 was highest from December through to May, after which it reduced between June and November, coinciding with the rainy season. As part of their response to load shedding GRZ and ZESCO are developing a pipeline of new generation sites (table 8). Additionally, through GET.Invest, two large-scale solar projects commenced construction in 2020 following the signing of a memorandum of understanding with the Zambian government. These will add a combined 200 MW to the national grid through a 135 MW facility in Northern Region and a 65 MW facility for the Copperbelt Region.

Table 8: Pipeline Generation Projects

GENERATION PROJECT	TYPE	CAPACITY (MW)	EXPECTED COMPLETION DATE
Kafue Gorge Lower Zambezi	Hydro	750	Completed (August 2021)
Lusiwasi Lower	Hydro	86	TBA
Lusiwasi Upper	Hydro	15	TBA
Musonda Falls	Hydro	10	TBA
Batoka Gorge	Hydro	1,200	TBA

Distribute

The National Electricity Grid is composed of the 330 kilovolts (kV) main line that spans a total of 2241 km across the country. Most power flows travel from the hydropower stations in the South to the Copperbelt province in the North, where the mines and main load centers are located. The rest of the transmission network consists of 348 km of 220 kV lines serving as interconnectors with neighboring DRC, Namibia, and Zimbabwe, 202 km of 132 kV lines and 754 km of 88 kV mainly in the Lusaka area, and 3033 km of load2 transmission lines, and 66 kV in the north-eastern and western parts of the country.

ZESCO plans on upgrading existing transmission infrastructures and developing new ones to new power plants that are currently being built. In addition to these projects, the country has planned further expansion of the national grid to the north-western province to new mining areas and developing new interconnectors with neighboring countries to increase power trade. The aim is to extend transmission and distribution networks to increase the rural electricity access rate from the current 4 percent to 51 percent by 2030. While in urban areas, the target access rate by 2030 is 90 percent (Vision 2030), up from 67 percent currently.

Table 9: Connection Rates by Urban/Rural, Urban Household Type and Province (adapted from LCMS 2015)

Category	Connected		Not Connected		Total
	%	#	%	#	
National					
Total	31	946,699	69	2,068,266	3,014,965
Rural	4	75,595	96	1,642,465	1,718,060
Urban	67	872,817	33	424,088	1,296,905
Urban – By House Type					
Low Cost	61	604,167	39	392,808	996,975
Medium Cost	88	147,090	12	19,490	166,580
High Cost	91	121,749	9	11,601	133,350
Province					
Lusaka	71	418,004	29	174,069	592,073
Central	20	57,242	80	234,807	292,049
Copperbelt	58	261,489	42	189,354	450,843
Eastern	8	26,689	92	315,472	342,161
Luapula	7	13,495	94	194,117	207,612
Muchinga	17	29,896	83	144,936	174,832
Northern	9	22,586	91	231,193	253,779
North Western	14	22,816	86	141,325	164,141
Southern	25	83,550	75	254,709	338,259
Western	6	11,953	94	187,262	199,215

Nationally, in 2015 (table 9), 31% of households were connected to the grid. Connection rates at the provincial level vary dramatically with a low of 6% in Western province and a high of 71% in Lusaka Province; Copperbelt had the second highest connection rates at 58%. Similarly, there is a significant disparity between rural (4%) and urban (67%) household connection rates. In urban areas, connection rates change in line with income levels with 61% of low-cost households connected, as compared to

88% of medium and 91% of high-cost households. In total, 418,004 households in Lusaka had connections (2015) with 261,489 connected in Copperbelt; totaling 679,492 households.

Retail

In 2014, Zambia had the lowest tariffs in sub-Saharan Africa, with the average Zambian tariff only 38% of the median one. This was made possible because ZESCO's variable cost of energy generation was minimal as almost all energy came from renewable hydropower which has no marginal cost associated with generation. On top of this, until the addition of the Maamba Coal Power Plant to the grid in 2016, the costs of ZESCO's large hydro power plants had been fully amortized (Trimble et al. 2016). In 2019, Zambia increased its electricity tariffs to better reflect the cost of generating, transmitting, and retailing electricity. However, even with the significant increase in cost, Zambia's average tariff is still the second lowest in the region (See figure 13: ERB Statistical Bulletin 2020).

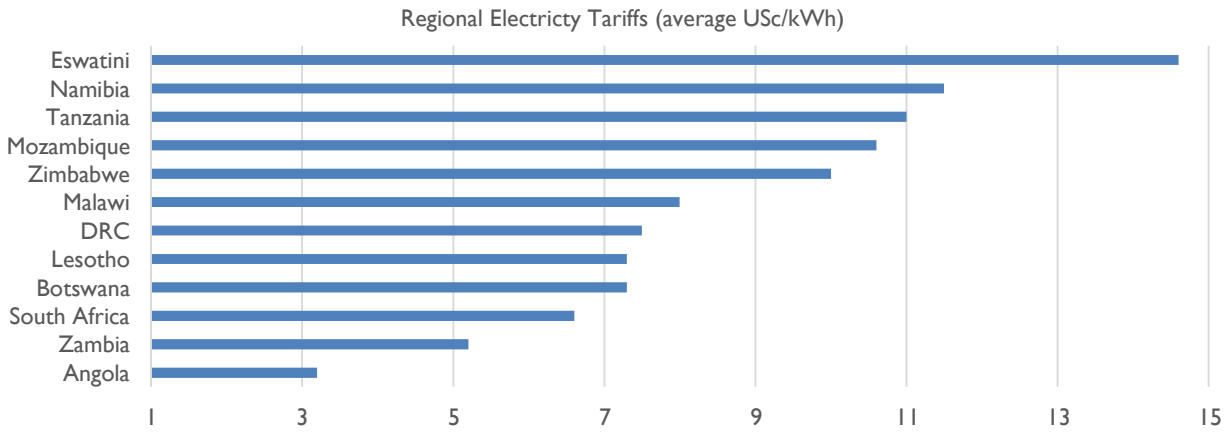


Figure 13 Regional Electricity Tariffs According to ERB

Figure 14 below shows the evolution of ZESCO's tariffs from 2010 up to 2020 (tariffs do not include the fixed monthly charge) and illustrates that residential tariffs have increased approximately four folds over 10 years, but most of the increase has come since 2018. As illustrated by Table 10 below, ZESCO introduced three tiers of residential tariff to ensure low-cost households could continue to access enough electricity to meet their basic needs. However, the highest tier of residential tariff (ZMW 1.94 kWh) is more than both commercial tariff rates.

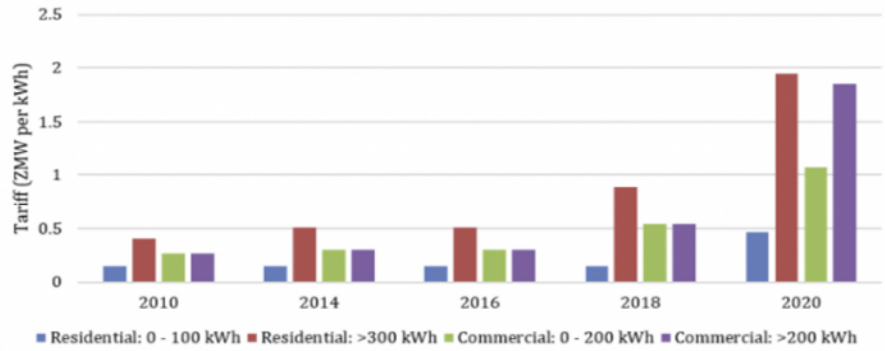


Figure 14 Evolution of ZESCO Tariffs (Source: The IGC)

Table 10: Comparison of Electricity Tariffs in 2019 and 2020

CUSTOMER CATEGORY	TARIFF COMPONENT	DEC' 2019 TARIFFS	DEC' 2020 TARIFFS
Metered Residential (Prepaid) – Capacity 15KVA			
R1 – Consumption from 1 – 100KWh in a month	Energy charge/KWh	0.15	0.47
R2 – Consumption between 101KWh – 300KWh in a month	Energy charge/KWh	0.89	0.85
R3 – Consumption above 300KWh	Energy charge/KWh	Nil	1.94
	Fixed monthly charge	18.23	Abolished
Commercial Tariffs (Capacity 15KVA)			
C1 – Consumption up to 200KWh	Energy charge/KWh	0.54	1.07
C2 – Consumption above 200KWh	Energy charge/KWh	Nil	1.85
	Fixed monthly charge	96.41	Abolished

In terms of appliances, users of electricity have a number of options that cater to a range of income levels and provide a variety of different cooking services (table 11). At the entry level consumers can purchase simple two plate electric hobs with prices ranging from ZMW 275 – ZMW 677, depending on the retail outlet. However, these only provide limited functionality and do not allow users to bake. At the next price point consumers can purchase a two-plate electric hob with inbuilt oven, with prices ranging from ZMW 1,295 – ZMW 3,123. Alternatively, Electric Pressure Cookers (EPCs) have been gaining increased prominence in the ATF sector as they are highly efficient, placing less burden on the grid and allowing them to potentially be powered by off-grid solar PV systems. EPCs currently retail for between ZMW 1,499 – ZMW 2,082 with prices increasing as efficiency increases. Finally, users of electricity can opt to purchase larger appliances such as the four-plate cooker with in-built oven, with prices ranging from ZMW 4,560 – ZMW 6,499.

Table 11: Household Cooking Appliances and Costs

Electric Appliances				
Product		**Radian**	**Game**	**ShopRite**
2 Plate Electric Hob 	Brand:	Kango	Sun Beam	
	Price:	ZMW 275	ZMW 677	
	Brand:	Kango		
	Price:	ZMW 425		
2 Plate Electric Hob with Oven 	Brand:	Superior	Salton	
	Price:	ZMW 1,295	ZMW 3,123	
Electric Pressure Cooker 	Brand:	Midea	Russell Hobs	Platinum
	Price:	ZMW 1,650	ZMW 2,082	ZMW 1,499

4 Plate Electric Hob with Oven		Brand: Price:	Defy ZMW 4,560	Defy ZMW 6,499	

Consumption

National electricity consumption for the year 2020 was approximately 11,481 GWh with the mining sector accounting for more than 50% (5,806 GWh), domestic consumption accounting for 34% (3,867 GWh), manufacturing, quarrying and construction 6% (716 GWh), agriculture 2% (261 GWh), finance, trade and property 6% (710 GWh), energy and water 1% (93 GWh), and transport less than 1% (29 GWh); figure 15 depicts the share of national electricity consumption by economic sector (ERB 2020).

Average household electricity usage is estimated to be 2.5 kWhs per day (ZESCO). Approximately 60% of household electricity demand is for cooking, and according to ZESCO, the highest consumption occurs during peak hour (19:00) when most households are preparing dinner; during peak hour, electricity demand is at least 2,100 MWh. Over utilization of electricity during peak periods has been stretching the capacity of the grid, resulting in "load shedding".

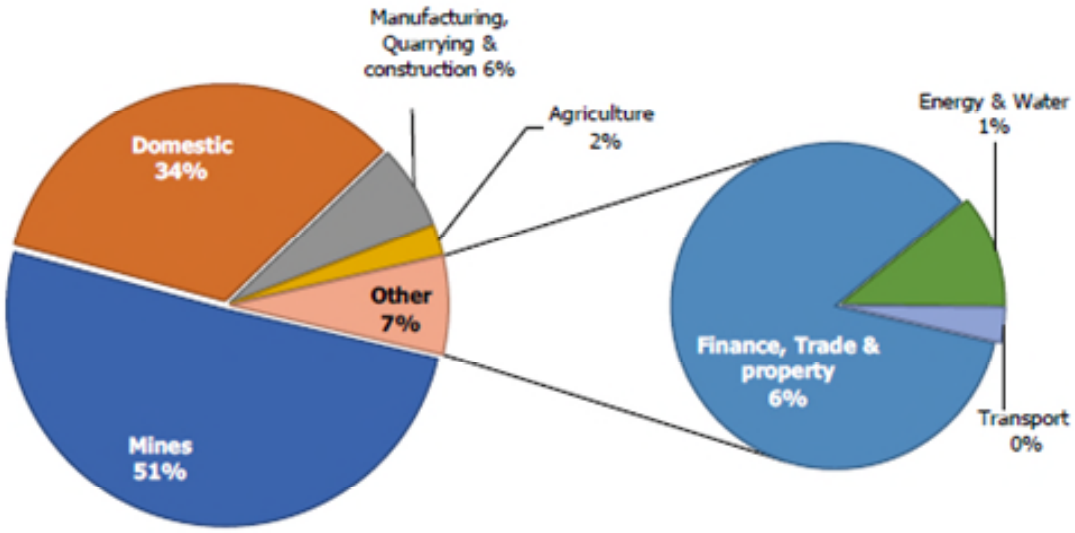


Figure 15 Electricity Consumption by Sector (ERB Energy Sector report 2020)

Data collected during the A2C Consumer Preference Study indicates that 98%, 87% and 60% of high, medium and low-income households have access to an electricity connection. While 82%, 53% and 24% (high, medium, low income) of households use electricity for cooking; they like that it is fast but are concerned about the cost. However, most households use it every day, but 69%, 40%, and 18% (H, M, L) stack electricity with charcoal. It is clear that electricity is the number one ATF in Lusaka and already plays a significant role in the household fuel stack. This is driven by the relatively low cost of electricity in Zambia and the high connection rates in urban areas. Not only is the fuel readily accessible and reasonably affordable, it is considered not just acceptable, but aspirational. Coupled with high awareness about, and accessibility of, electric cooking appliances, that cover a range of uses and prices, it is clear to see why it has become such a widely used cooking option. However, adoption of electric cooking does

fall dramatically as income levels fall. Furthermore, "load shedding" is a significant, mainly seasonal, issue which negatively impacts consumers ability and willingness to fully depend on electricity for cooking (Consumer Preference Survey, 2021). Figure 16 illustrates the monthly electricity expenditure per income bracket (low – less than K1,500, Medium – K1,500 to K3,000, and High – more than K3,000) and their subsequent distance to purchases of electricity (with 0 km indicating digital purchase) to show accessibility of electricity by consumers.

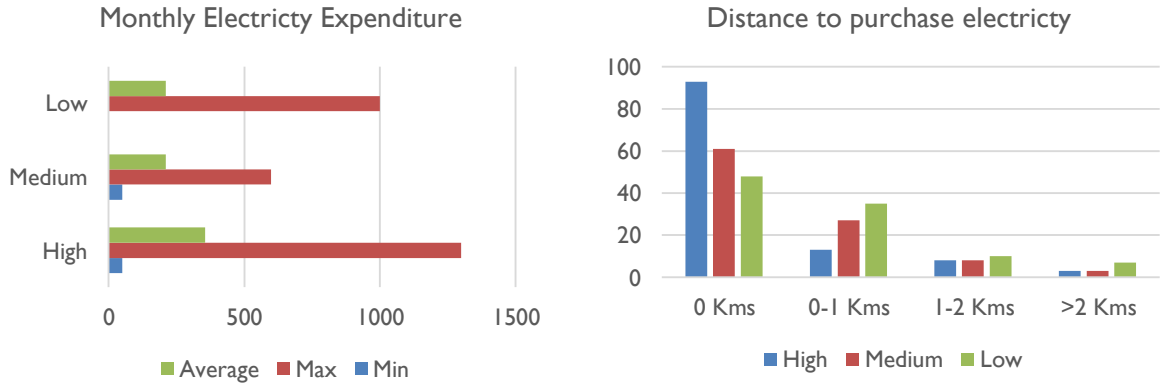


Figure 16 Monthly Electricity Expenditure and Distance to Purchase by Income Level (A2C, Consumer Preference Study)

INPUTS, SERVICES AND FINANCE

Financing for electricity in Zambia for power producers is largely available from the Zambian government through the Industrial Development Centre (IDC) to partner with private investors on financing framework in the energy sector. Beyond this, below is some financing made available to the sector by development partners:

1. Through the Off-Grid Energy Access Fund, the Zambia Renewable Energy Financing Framework program was initiated (2018/2019) to be co-financed by the Green Climate Fund (GCF) and African Development Bank (AfDB). The objective for the fund is to support the Government of the Republic of Zambia in its efforts to catalyze private investment for small-scale renewable energy projects and thereby accelerate the achievement of Zambia's electricity generation targets and the diversification of its energy mix. The program aims to finance 100 megawatts of renewable energy independent power producer projects and offer technical assistance to scale-up renewable energy investment in Zambia. Further, the Off-Grid Energy Access Fund supports financially sustainable transactions that engage local capital markets to increase access to clean electricity for underserved households by providing flexible debt instruments to companies in the household energy access sector including consumer credit providers, manufacturers and distributors.
2. Beyond the Grid Fund for Zambia (BGFZ) is an ambitious multi-year program aiming to increase energy access, improve livelihoods and catalyze economic activity in rural and peri-urban areas. The BGFZ aims to bring modern energy services to at least 167,000 households – translating to one million Zambians – by 2021. The core of the BGFZ is a EUR 20million results-based "social impact procurement" fund. The BGFZ is designed not as a standalone initiative, but rather to augment and complement various other programs and activities, including those which support large-scale power production, transmission, and distribution via the central utility grid.
3. GETFiT Zambia; designed to assist the Zambian Government in the implementation of its REFiT Strategy and aims to procure and support Independent Power Producer (IPP) projects up to 20 MW. The procurement and support of 200 MW renewable energy capacity are at the core of the Program, divided into a 100 MW solar PV round, and a 100 MW small hydro round. Additional

components of the Program aim to boost institutional capacity and enable a transparent regulatory framework for private sector participation. The GET FiT Program is executed by the Zambian Ministry of Energy, and implemented by the German development bank KfW. Program funding is provided by the German government. In addition, a multitude of Zambian stakeholders is involved, such as ERB, ZESCO and OPPPI. Other cooperating international organizations include the African Development Bank, and Africa Trade Insurance.

ENABLING ENVIRONMENT

Zambia's SE4ALL Action Agenda sets out a vision for modern and clean cooking solutions in urban areas by 2030. This vision follows a 20-40-20-20 scenario that aims to move urban cooking to 20% electricity, 40% LPG, 20% charcoal and 20% firewood. This would necessitate reducing electric cooking from 35% and charcoal use from 59% (2015), while increasing use of LPG from <1% and firewood from 6%. However, the Action Agenda does recognize that it is highly likely that electricity will remain the preferred source of energy for cooking in urban areas in the short to medium term but predicts that in the medium to long term this will shift in favor of other alternatives, such as LPG, as electricity tariff adjustments take effect, pushing the cost of electric cooking up.

In 2019 the Energy Regulatory Board commissioned a Cost-of-Service Study to inform future electricity tariffs with the aim of ensuring financial viability of the electricity sector and providing a pathway to transition from the existing financial-cost based tariffs to economic cost-based tariffs. This will include determining the level of electricity requirement for poor households to meet their basic needs with the view to implementing a revised life-line tariff. However, it is not clear how "basic needs" are defined and whether these include electricity for cooking and which cooking appliances this definition is based upon. Given the high cost of LPG, and challenges with availability, it is possible a push to increase electricity tariffs will drive low-to-middle income households back towards charcoal with hugely detrimental impacts on the environment. Therefore, the outcome of the Cost-of-Service Study and the impacts on electricity tariffs will be critical to the grid-based electric cooking sector.

While the long-term GRZ strategy is to move households away from cooking, the goal is to increase electricity connections from 4 percent to 51 percent in rural areas and 67 percent to 90 percent in urban areas (Vision 2030). To achieve this GRZ intends to establish an Open Access Regime in the electricity sector which allows for any party selling or buying electricity to use transmission and distribution systems without discrimination. This in principle allows IPPs to sell to third party market operators, or directly to anchor consumers, and pay wheeling charges. However, this open access regime still needs to be fine-tuned. Although the law is progressive, in practice the Act does not guarantee access as there are provisions for matters to be referred to the ERB. In addition, the Electricity Act appears to give the ERB unilateral powers to intervene and review tariffs and contracts, which is considered risky and not bankable by IPPs and developers (Draft National Renewable Energy Strategy 2021). By opening up the electricity sector, the Open Access Regime will allow for increased investment and private sector participation, increasing the likelihood of Zambia meeting its electrification targets, with knock-on effects for the future of grid-based electric cooking in Zambia.

A combination of poor macro-economic conditions and ZESCO's insolvency is adversely affecting the power sector in general, and renewable energy in particular. Currently, ZESCO is de facto single off-taker for grid connected projects. Several IPP projects are now in limbo as IPPs have been unable to secure funding and sign power purchase agreements (PPAs) with ZESCO. With the removal of government-backed sovereign guarantees, financiers are unwilling to provide funding to project developers supplying ZESCO due to its poor creditworthiness. Resolving ZESCOs insolvency is therefore critical to increasing investment in the electricity sector, allowing for increased generation, distribution, connections, and ultimately electric cooking (Draft Renewable Energy Strategy 2021).

To ensure sustainable and reliable provision of electricity, ZESCO has embarked on information dissemination campaigns through their demand side management program to encourage users to choose other times for cooking meals and to practice a 'switch and save' system of electricity usage. As part of this campaign ZESCO has been educating consumers on what energy saving appliances exist, to make to ensure the grid is not overburdened. Once such campaign requested households to switch to LPG for their cooking needs. This, coupled with extensive loadshedding, resulted in an uptick in residential LPG usage, but this was not sustained as households switched back to electric cooking, or charcoal.

5.2 EMERGING MARKET DEVELOPMENTS AND INNOVATIONS

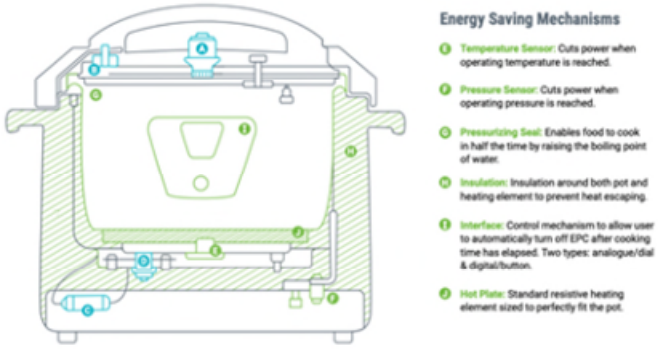


Figure 17 Energy Saving Mechanisms for Electricity

EPCs are a new generation of electric cooking technology that offers an alternative to biomass cookstoves while presenting a long-term solution to biomass fuel-driven environmental degradation and a viable path towards total eradication of indoor air pollution. For women, EPCs can reduce the time spent collecting fuel and unlock time for other responsibilities and income-generating or educational opportunities. Research found that it is possible to cook over 90% of Kenyan meals in an EPC. Of course, 'heavy foods' like beans are what it does best. The MECS kitchen laboratory experiments for the Kenya eCookBook showed that pressurizing the cooking pot reduces cooking times by half and combined with the insulation and automatic control, energy consumption is reduced by up to 90%. However, it can also cook staples with shorter cooking times like rice and potatoes. These efficiency features significantly reduce the cost of cooking for households, as well as energy demand for on and off-grid scenarios.

5.3 BARRIERS AND SUPPORTING INTERVENTIONS

Table 12: Electricity Barrier and Supporting Interventions

Market System Issue	Support Intervention
Enabling Environment	
Affordability: Households believe cooking with electricity to be expensive, even though Zambia has one of the cheapest tariffs in the region and multiple studies (CEADIR and MECS) have determined that electric cooking is the least cost option.	Technical Assistance: Through its SBCC campaign A2C should concisely communicate facts about the low cost of cooking with electricity to ensure consumers can make informed decisions about their ATF choices.
Policy: Through the SE4All Action Agenda and the Ministry of Energy Strategic Plan, 2018-2021, Zambia has set targets for cooking that aim to reduce urban electric cooking from 35% to 20% and increase woodfuel use from 6% to 20%, while at the same time increasing LPG use from <1% to 40% by 2030. While the rationale is understandable, there is potential that households will be driven away from electric cooking and many will return to using charcoal.	Technical Assistance: A2C should work with GRZ and other development partners to develop a National Clean Cooking Strategy that clearly set's out a pathway to meeting these targets and assess the practicality of increasing woodfuel use and decreasing electricity use in urban areas.
Value Chain	
Generation: Generally, most of the generation capacity comes from the state parastatal, ZESCO, and is	Technical Assistance: Support should be provided to GRZ to fine tune the Open Access Regime so that it

delivered from hydro-power stations, with limited private sector involvement. This has contributed to the significant load shedding in the country, due to demand outpacing supply. While Zambia is moving towards an Open Access Regime it needs to be refined to bring confidence to the private sector and result in bankable projects.	brings confidence and security to private sector developers and financers. This will help to increase investment in the sector and increase power generation capacity, reducing load shedding. Emphasis should be placed on investments that diversify the range of generation sources, so that the country is less reliant on hydro-power. **However, while critical, this intervention is outside the scope of the A2C project.**
Retail: Even though electricity tariffs have recently increased, they are still not economically viable for ZESCO, reducing the utilities' ability to maintain and invest in power generation and distribution, contributing to load shedding. Furthermore, the current tariff structure, and ZESCOs financial difficulties, mean that private sector investors are unwilling to enter into agreements with the utility.	Technical Assistance: Support should be provided to GRZ to ensure the Cost-of-Service Study is completed and the recommendations adopted. While this is outside the scope of the A2C project, support should be provided by A2C in developing the lifeline tariff levels and defining what is covered under "basic needs". Is cooking included as a basic need and on what electricity consumption basis, utilizing which cooking appliances? Inclusion of a certain amount of electric cooking as basic need will help to keep the cost of cooking on electricity affordable for those in the lowest income groups.
Consumption: Peak demand for electricity is at 19:00, coinciding with when households are preparing their evening meals. This often places a significant load on the grid and exacerbates load shedding.	Technical Assistance: Through its SBBC campaign A2C should work with ZESCO to encourage households to cook outside this peak hour and educate consumers on the range of more efficient appliances that they can adopt, for example Electric Pressure Cookers, or induction hobs.
Inputs, Services and Finance	
Tenancy Agreements: The A2C Consumer Preference Study found that landlords in lower cost housing areas forbid electric cooking as part of tenancy agreements.	Technical Assistance: A2C should work with Lusaka City Council and landlords to better understand the rationale and change this practice, so that more lower income households can practice electric cooking.

6. BIOMASS & BIOGAS

6.1 BIOMASS MARKET SYSTEM

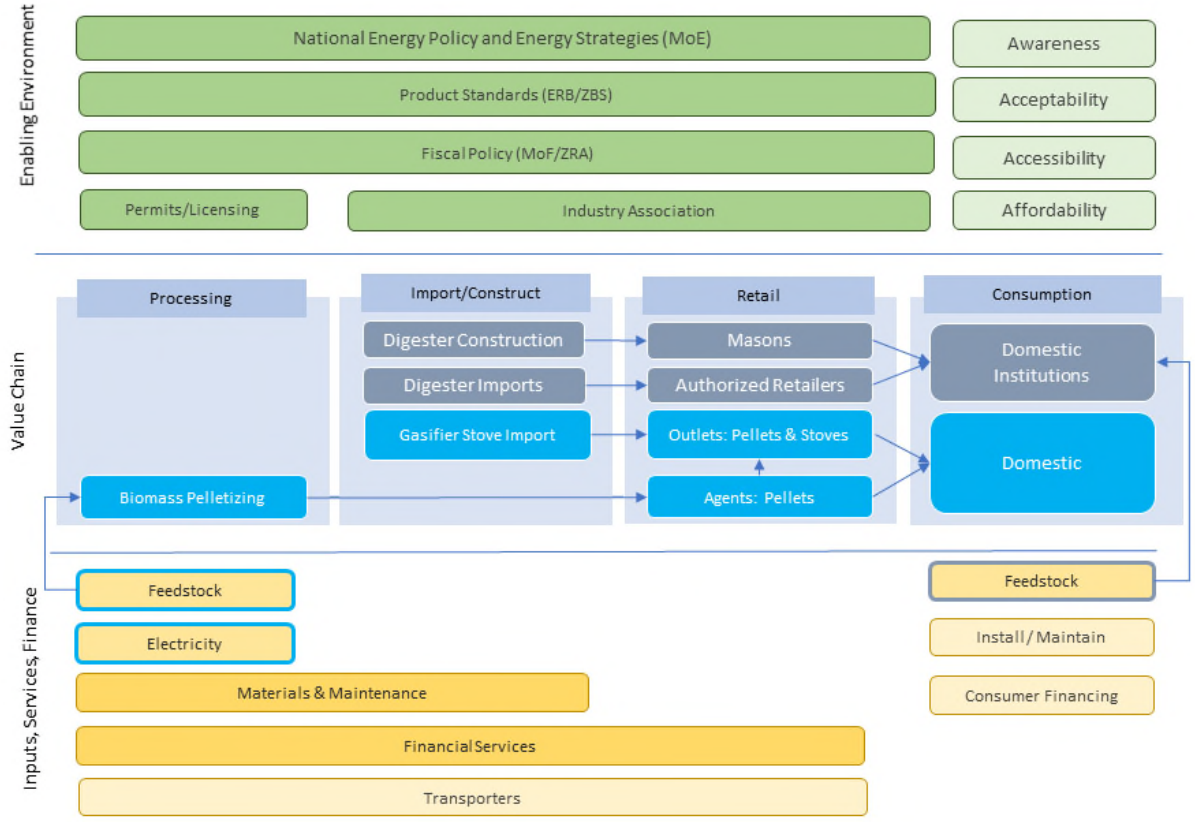


Figure 18 Biomass Market System

VALUE CHAIN

The biomass section of this market assessment combines two ATF models, biogas and processed biomass fuel, in the form of pellets which are combined with highly efficient gasifier stoves. Both markets use biomass feedstock to provide cooking energy and both markets are highly underdeveloped in Zambia, with very few actors and limited available information. The bright blue boxes in the market system diagram indicate the pellet fuel and gasifier stove value chain, while the dark grey boxes indicate the biogas value chain. The biogas market in Zambia is dominated by rural, household digesters which are constructed by masons. However, Sistema HomeBiogas has also established an authorized dealer in Zambia who imports fully manufactured, inflatable biogas systems onto the market. Furthermore, while none are currently operational, larger institutional biogas systems could be a viable option in urban markets, providing gas to nearby food vendors, or potentially households if bottled for home consumption.

Biomass feedstock in Zambia is composed of four major groups, namely: forest plantation residues; wood processing residues; crop residues; livestock residues. The focus of this analysis is on the forest plantation and wood processing residues as these are the inputs required for biomass pellet production used by the main producer in Zambia, Emerging Cooking Solutions (ECS). Pellets trade under the SupaMoto brand and ECS retails gasifier stoves - the Mimi Moto stove - for use with their pellets. When

Mimi Moto stove is used with good quality pellets the emissions easily comply with the WHO's stringent air quality guidelines.

There are no other known companies (commercially) producing and selling biomass pellets though a partnership between two groups – Green Enviro Watch and Climate Smart Agriculture Alliance Zambia (CSAAZ), piloted biomass pellet production using grass, crop residues as well as forest and timber residues. After an in-depth exploration of the viability of the business, the groups concluded that at scale, and assuming the cost of their biomass pellets is less than that of charcoal, the demand for the pellets would soon outstrip the supply of main inputs. Lastly, without external funding the setup cost of the production facility was inhibitive. At the time of compiling this report, the group had not yet started operations.

Biomass Processing

Companies producing biomass fuels can make a request through the national Department of Forestry to collect forest residues which are then allocated and charged by ZAFFICO. Harvesting of tree plantations is conducted once a year. It is estimated that approximately 10 to 20 per cent of forest residues available for biomass fuel production are collected through plantation harvesting. It is also reasonable to assume that there is more harvest waste that is collected and unregistered, though there are no estimates of how much residue is collected in this way. Given that an estimated 40 per cent of residues are already being used, this leaves only 40 percent potentially available – which translates to less than 60 thousand tons of residues - for pellet production.

The amount of wood processing residues available for bioenergy production is calculated by the recovery rate at sawmills which translates to the ratio of saw wood to roundwood. Residues produced in sawmills include chips, shavings and sawdust. The limitation in this calculation is that official data on the volume of roundwood processed by sawmills in Zambia has not been documented and published in a systematic manner. Despite the reported limitations in data, it is estimated that 145 715 m^3 (72,858 tons) of residues would be available for bioenergy production annually. Consequently, the risk to fuel producing companies in this sector, or looking to enter this market, is inconsistent data on available inputs based on which they can make projections on production potential.

While the forest plantation residue used to produce pellets are locally based, the plantations are in some of the remote parts of the country's Northern Province. Despite the established road network, it becomes impassable in the rainy season - limiting activity and access to some forest plantations. The production of pellets is currently based in the province in an attempt to minimize transport/logistical costs.

Both the hammermill and pelletizer machines used in pellet making are imported into Zambia at an estimated landing cost of 1 million US Dollars (for both) brand new machines and 400,000 US Dollars for used machines. The manufacture of wood pellets involves the following steps: (1) Raw material receiving; (2) Wood residue; (3) Chipper; (4) Dryer; (5) Hammer mill; (6) Pellet mill; (6) Cooling zone; (7) Bagging/storage.

The raw materials are uniformly dried to a low moisture content between 12-14 per cent of feedstock to avoid poor consolidation of the pellet. While on one hand the hot Zambian season weather lends itself to aiding this process (thus cutting down time in a dryer). The rain season equally complicates the production process, making working with sawdust especially difficult because it absorbs moisture. The weather sensitivity of biomass energy also requires well ventilated storage facilities for protection from the rain (and moisture). Once dried, the wood is fed into a hammer mill to produce wood particles of a consistent size.

Pellets are then extruded using high pressure and temperatures in a pelletizing machine. The operating expenses of the machines, particularly electricity (or diesel), and their maintenance costs can result in

high production costs. The current monthly production capacity of SupaMoto is 400 tons per month and the company plans to soon upgrade to 800 tons per month when new equipment is installed.

Despite the growth in output to date, the high cost of electricity and erratic availability due to load shedding in Zambia poses a challenge to pellet production in the country. There is also the cost of the forest residue (ZAFFICO) which saw an increase in early 2021.

Import, Construct, Distribute and Retail

Biomass: Once pellets are formed and cooled, they are packaged in bags or stored in bulk. Through SupaMoto, they are available to household consumers in 20-kilogram bags priced at ZMW60/3.50 US Dollars. The main challenge with (bulk) storage of pellets is their large storage requirement and that they to always be kept in a dry place. Pellets are distributed through shops located in major centers and networks of agents buy them at a discounted price and resell in their respective communities. Pellets are also distributed through sales outlets of other energy partners and large retail outlets and supermarkets in most parts of the country. Customers' payment options are cash, mobile money and payment plans (if purchasing the stove whose total cost is 2,950 ZMW/175.50 US Dollars).

Biogas: There are a range of different models and sizes of biogas digester that can be constructed or manufactured. The FAO Bioenergy and Food Security Study identified the main three types below, but in addition to these, Home Biogas systems are available on the Zambian market, which are manufactured outside of Zambia and imported onto the market.

The fixed dome biogas digester consists of a digester with a fixed, non-movable gas holder that sits on top of the digester. As the volume of the gas produced augments, in turn the pressure of the gas expands and the difference in height between the slurry level in the digester and the slurry level in the compensation tank increases. This then pushes the slurry into the compensation tank where the excess overflows. All steel components are made of stainless steel; hence the life of the plant is around 10 years. The plant is constructed underground to save space and protect it from physical damage.

The floating drum biogas digester consists of an underground digester and a moving gas holder. The gas holder floats either directly on the slurry or in a water jacket of its own. The gas is collected in the gas drum, which rises or moves down according to the amount of gas stored. It may be necessary to replace the steel or plastic components during the lifetime of the system. The lifespan of the drum is around 10 years.

The tubular or polyethylene bag consists of digesters built from two layers of polyethylene plastic in a tubular form. The tubular digester is placed in a trench with a slope to facilitate gravity flow. It is the least expensive system and the easiest to construct, however its lifespan is a mere 5 years.

At the sectoral level there are many masons trained to build biodigesters (majority of whom are trained under the SNV program) throughout the country, though their co-ordination is limited. The SNV-trained masons have further benefited from being a part of a network through benefits including introductions to dairy farmers and associations (in Southern, Eastern and Lusaka provinces) who can in turn become biodigester customers.

The greatest challenge to businesses in this sector is logistical, particularly as it affects access to customers. Business owners indicated higher sales volumes in areas where roads were passable. The state of roads in some parts of the target communities also makes it access in small cars difficult. In instances where they had been able to service customers, the challenge became their access to provide after-care services such as maintenance of the biodigester and safety screenings to ensure that there were no gas leakages.

Biogas digestor construction is highly reliant on the size of land available as well as feedstock. Price is also a key driver in consumers' choice of product. There are two main modes of payment for available biodigesters, they are cash and a value equivalent of the materials and labor.

Table 13: Domestic Biogas Products

Domestic Biogas Products					
	Biodigester Size	Price (ZMW) (*labor & materials*)	Fertilizer output (in Kg/day)	Feedstock required	Electrical output
Rural	6 m^3	13,200	50	2-6 animals 6-8 people	-
	9 m^3	17,100	100	8-14 people	-
Urban	14 m^3	20,400	150	6+ people	-
	21 m^3	23,800	250	2 households	-
Peri-urban	30 m^3	35,700	350	-	3-5 KVA
	40 m^3	47,300	450	At least 10 households	5-7 KVA

Table 14: Commercial Biogas Products

Commercial Biogas Products			
Biodigester Size	Price (ZMW) (*labor & materials*)	Fertilizer output (*in Kg/day*)	Electrical output
50m^3	119,800	550	10KVA
60 m^3	126,380	700	12 KVA
80 m^3	141,200	950	15 KVA
100 m^3	145,400	1100	20 KVA
200 m^3	289,900	2000	40 KVA

Consumers

Biomass: According to a BEFS (2019) survey, Zambian urban households consumed 4 kg per day of charcoal and 15 kWh/day/hh of electricity. By contrast, the same households consumed 2 kg per day of pellets for cooking, making it a significantly less popular fuel source. The low consumption rate of biomass pellets may be attributable to the fact that they have to be burned in modern cook stoves, whose combustion is designed to be most efficient for burning pellets. The challenge to the biomass sector is therefore two-fold; on one hand the sector is faced with a behavioral change challenge of getting consumers to shift from a reliance on charcoal to biofuels; on the other hand these fuel types are most efficiently used in a particular type of stove whose cost remains high (by comparison to the mbaula used with charcoal cooking).

Biogas: Depending on the businesses, cash paying customers make a down payment of between 20 and 60 per cent of the price of their biodigester and pay off the remainder upon completion. One business gave customers provision to pay off the balance in 3 installments to reduce the affordability barrier. Unfortunately, even with these provisions in place to try and make repayment more manageable for customers, business indicated that default rates remain high. To try and mitigate these high default rates, one business is looking to increase both his customer footprint and mitigate defaults through a sponsorship model where a funding organization or NGO pays for the biodigester upfront, and the customer repays the organization over an agreed period. The model therefore presumes that there is a benefit to the organization to take on the debt. The other method of payment commonly used for biodigesters – particularly in servicing farmers – is what they refer to as 'in kind payment equivalent'

wherein an agreed value of materials and labor is pegged to another valuable item such as a piece of land or livestock. This payment method is especially common in rural communities where customers and business own cattle or have access to land-based assets.

At consumer level, the responses of biogas producers suggest that biogas awareness seems higher amongst farmer and rural communities (compared to urban communities). This is likely attributable to the high reliance of biodigesters on animal and agricultural waste for feedstock. To increase awareness and market share, one business has redesigned a biodigester so that it can generate electrical power compatible for use with a generator, to be readily used for lighting and connectivity to other electrical appliances. Businesses also expressed an interest in the construction of demonstration sites and their potential to educate more people about biogas and how biodigesters work.

Even with this innovation, the storage and transportation of the gas remain a limitation for biogas access to consumers with no agricultural waste. According to one business owner, the solution to this challenge is packaging and compressing the gas for consumers in urban and peri-urban areas located further away from the biodigester. Also, if a centralized biogas production site distributing gas to several households was considered another innovative way to ensure greater biogas consumption.

INPUTS, SERVICES AND FINANCE

Biomass: There are about 57 000 hectares of plantation forests in the Zambia – this includes industrial plantations which stands at approximately 50 000 hectares while the rest are local supply plantations. The Zambia Forestry and Forest Industries Corporation Limited (ZAFFICO), a state-owned enterprise develops and maintains pine and eucalyptus plantations for the harvesting and commercial processing of timber to supply timber to the foreign market. ZAFFICO plantations are spread over the Copperbelt Province in Ndola, Kalalushi, Chingola, Lufwanyama, Mfulira and Kitwe. A recent expansion program to meet the growing demand for timber has resulted in further plantations in Luapula and Muchinga provinces. However, biomass-waste pellet production from plantation forest residues in the country is in its infancy - with only one company known to produce biomass waste pellets.

The production of biomass energy requires the highest investment – particularly the cost of machinery. The under-developed status of the industry in Zambia and added lack of industry association makes it difficult for individual biomass energy producers to scale-up their production, attract a critical mass of consumers and in turn make the business case for investment into the sector. Critical cost items such as the machinery, factory space and warehousing land solely on the entrepreneur. The inconsistent pricing of forest waste and unpredictable amount available further complicates businesses' ability to project costs of running the business. Guarantees of product availability, supply and cost would help biomass production businesses across the value chain.

Biogas: Biodigesters convert organic matter like animal manure, human excreta and food waste into combustible gas, known as biogas. Smallholder farmer households with at least two cows or seven pigs can generate sufficient gas to meet their basic energy needs: clean cooking and basic lighting. The resulting bio slurry, either direct, or in the form of bio compost, can be used as organic fertilizer to produce crops and fodder. Another critical factor is the feedstock quality. Ideally, there should be large amounts of organic matter available for digestion and an adequate carbon-to-nitrogen ratio. Therefore, the most common raw materials for biogas include livestock residues, specific crop residues, agricultural waste, municipal waste, green waste, and sewage sludge

In Lusaka Province there is an estimated 187,000 tons of animal manure available and accessible for biogas production, of which cattle contributes 110,000, pig 65,000, chicken 10,000 and goat 2,000 tons. Public markets across Lusaka, including the Soweto vegetable market, generate large quantities of waste every day. The waste is usually taken to a landfill close to the market before being transported to a larger city landfill on the outskirts of Lusaka (80% of the total waste in the landfills is organic). Tons

of organic waste from vegetables and fruits disposed at local markets are left unused and unprocessed in city landfills where they emit large volumes of carbon dioxide and methane, both powerful greenhouse gasses and significant drivers of global warming. Moreover, waste stored in large landfills contributes to land, water and air pollution and leads to public health risks.

ENABLING ENVIRONMENT

Biomass: To access the wood (waste) from any woodlot in Zambia, users need to be licensed under the Forest Act 2015 (4) according to which the Department should regulate and control the use of all forest species. However, the Act is unclear on how this is to be applied specifically to commercial plantations. Consequently, the regulation of commercial forest plantation in the country are not uniformly enforced. The Forestry Department has made attempts in the past to draw up regulations to guide plantations, particularly in price setting. When this is finalized, it will likely be easier to regulate in government-owned plantations but in their enforcement in commercial forest plantations may be more of a challenge. Further, by Zambian law, all wood products transported in the country need a conveyance license. However, this too is said to be weakly enforced.

The Forestry Department also advocates for greater private sector engagement through its Maximum Utilization of Forest Resources. The collection of forest plantation residue fall under this category and it is meant to encourage minimal forest residue waste and greater natural resource reuse. That said, the inherent motivation of commercial plantations is profit maximization, therefore it is not surprising that they continue to sell their forest residue. In the case of ZAFFICO, it was privatized in November 2018 and despite some government shareholding in the entity, its focus has been significantly more profit oriented. This has been reflected in its recent price increase on forest residue at all its plantations.

The challenge to consumers of these residual forest products has been the lack of a coherent pricing schedule. Companies in need of forest residue are also not guaranteed of a specific amount of forest residue as plantations are non-committal on the sale of pre-defined amounts of residual product. For companies producing fuel from biofuels from the from the forest residues this presents a real challenge to their production planning and input projection.

To date, Zambia does not have a national clean cooking association but plans to start one are underway in partnership with the Offgrid taskforce and SNV. The Off Grid Task Force was launched by the Power Africa – Beyond the Grid Fund for Zambia (BGFZ) in 2016 to help support private sector-led energy service provision and stimulate the local energy market. Under BGFZ, ECS has moved into regions of the country focusing on cooking solutions. However, the Off-grid taskforce remains focused largely on off-grid energy and given the more advanced status and size of the solar industry in Zambia, more of the activities of the task force have been with a focus on clarifying and improving the regulations, policy and market approaches focused on the solar sector. Despite its small size, the clean cooking and pellet producing businesses leverage access to the taskforce, especially to engage the Zambian government – particularly in the imposition of taxes on pellets. Pellets should be VAT exempt in Zambia but there is no official communication from the Zambian Revenue Authority (ZRA) to that effect. Consequently, VAT application on the fuel is not uniform.

Both biomass and biogas energy businesses are guided by the Energy Regulation Board (ERB), which sets out the following requirements for obtaining a license to establish biomass energy production facilities in Zambia:

- 5 years (for first time applicants) or 3 years (for renewals) Business plan
- Latest audited financial statements (if business is already Operational)
- Latest annual returns from PACRA
- Certificate of incorporation

- Proof of funds, i.e., six months bank statement or Documentation showing commitment from sponsor (s) with Board resolution
- List of shareholders and directors from PACRA
- Certified copies of national registration cards (NRC) or Passports of Directors

Biogas: As of 2014, the sector has draft safety standards through the Zambia Bureau of Standards (to date they remain in draft). The sector is governed by the National Biogas and alternative Energy Association based in Lusaka. However, it is unclear whether membership to the association is mandatory or the mandate of the association. In fact, some of the businesses were unaware of the association while the current members reported unclear association goal and irregular meeting times. Businesses expressed an interest in getting more Government support through a policy that will help the growth of the sector and attract greater investment to the sector. While some Biodigester businesses adhere to safety standards supported by SNV, others reported following building standards with no specific reference to ensuring biodigester safety.

One of the key drivers of biogas market expansion in Zambia has been SNV Zambia, a Netherlands development organisationthat provides capacity development services including training masons to build biogas technology. SNV has especially focused on getting more and more young women working in biodigestor construction throughout Zambia. To date, SNV have supported the development of over 50 biodigestor construction enterprises. The biogas produced in Zambia is for domestic use (cooking, heating and brooding) and is concentrated in the rural and peri-urban parts of the country because of its high reliance on farm waste for biodigester feedstock. Feedstock includes animal manure, human excreta and agricultural plant waste.

6.2 EMERGING MARKET DEVELOPMENTS AND INNOVATIONS

To date, the pellets produced by ECS are sold together with their efficient burning range of stoves. However, there are similar stoves on the Zambian market that can burn the pellets efficiently – making the pellets more sustainable in terms of their adaptability of use across a range of stove types.

Examples can be drawn from the Ace One stove produced by Africa Clean Energy (ACE) with manufacturing facilities in Lesotho. The Ace One is a solar-biomass hybrid system that can burn and dry solid biomass fuel including animal waste, crop residue, small sticks and pellets. The burning chamber of the ACE One is designed to reduce smoke emissions to a negligible level by creating clean biomass combustion. The ACE One stove has a fan regulation mechanism for high and low heat. At full/high fan, the stove can burn 750 grams of pellets for 50 minutes and at low fan the same amount of pellets burn for up to 100 minutes.

The added features of the stove are an LED lamp (100 lumens) and a 10Ah battery build into the stove. The ACE One retails at approximately 120 US Dollars and customers can make flexible, incremental repayments on Pay-As-You-Save (PAYS) model for a 12–15-month duration until the full value of the stove is paid off. Data collected by ACE shows that ACE One stove customers can make up to 83 per cent savings compared to other commonly used cooking fuels such as paraffin. In Lesotho where the stove is largely consumed, the monthly installments make it affordable to a wide range of households regardless of income.

A large part of the stove pricing is because it is assembled locally but fuel in Lesotho remains a significant challenge because of the country's under-developed alternative fuels market. ACE is looking to expand

into other country markets and Zambia is one of them. The ACE One would be a good compliment to the existing pellet production in the country and may even help the growth of pellet manufacturing.

6.3 BARRIERS AND SUPPORTING INTERVENTIONS

Table 15: Biomass & Biogas Barriers and Supporting Interventions

Market System Issue	Support Intervention
Enabling Environment	
Industry Association: There is no biofuels or stove association to coordinate and harmonize the activities of the two subsectors and increase negotiating power.	Technical and Financial Assistance: Support to bioenergy and stove companies to create an association whose aim is to represent the needs as identified by the sector itself.
Machinery purchase and maintenance: Machines are purchased overseas and quoted in foreign currency, making upfront costs significantly high.	Technical Assistance: Support through technical training institutions to grow technical expertise on building and/or maintaining machinery used in the sector. Leverage A2C network of financiers and investors to provide loans/grants towards the purchase of machinery.
VAT exemption on inputs: Incoherent position of VAT on business inputs and a lack of written regulations make it difficult for businesses to plan/forecast their expenditure.	Technical Assistance: Support industry association to lobby for VAT exemption or rebates on inputs to promote their acquisition – particularly technologies unavailable in Zambia.
Value Chain	
Sale and Distribution: Business models in this sector are highly dependent on word of mouth and reseller agent networks. It is important for businesses to build a reliable brand, consistently deliver their service and grow their sales footprint.	Technical assistance: Support businesses on marketing their product, training their agent field staff on customer service and retention in the ATF sector.
Accessibility: Biofuels produced in this sector require a lot of storage space, posing a challenge to the manufacturer in the production phase and the consumer in the distribution/consumption phase.	Technical and Financial assistance: Businesses can leverage the A2C grant facility and access to the network of financial institutions for a grant/loans to purchase storage to make access to their fuel more easily accessible to consumer households without being limited by available space.
Domestic households: The fuels producers in this sector would like to expand their products to urban/peri-urban households but awareness raising and availability of their product to these households is limited.	Technical Assistance: A2C can support businesses to better advertise their products to their target consumer households and support the sector to raise greater awareness on the benefits of bioenergy sources.
Modern cookstove consumers: Technical matching-making to grow the network of service providers in the clean cooking sector who can service the consumers of modern cookstoves, including fuel producers in an effort to grow the sector as a whole.	Private-sector match-making: A2C has access to a growing network of private sector players in the ATF sector broadly that can complement ones another's critical business need areas.
Inputs, Services, Finance	
Investment and Financing: There are numerous financing needs across the value chain, particularly at the production phase associated with the acquisition of machinery and packaging for example.	Technical assistance: Support the industry association with information on available funding sources for business development, expansion, and acquisition of inputs. A2C itself does not finance business assets such as machinery.

Consumer Financing: Reduce the upfront costs of ATFs to stimulate household adoption/use. Innovative payment methods such as PAYGO and hire-purchase can be developed and adopted for the sector.	Technical Assistance: support private sector matching for cross-pollination of businesses needs and solutions available in the Zambian economy and other markets.
Feedstock access pricing, permitting and enforcement: Access to some feedstock (e.g. forest waste) requires permitting and enforcement of the permits to ensure all users pay stipulated fees and penalties for non-payment are imposed. Prices on feedstock should be uniform throughout the country.	Technical Assistance: support the industry association to lobby for clear price setting and enforcement of the relevant statutory instruments for greater transparency, accountability and fairness.

7. ETHANOL

7.1 MARKET SYSTEM

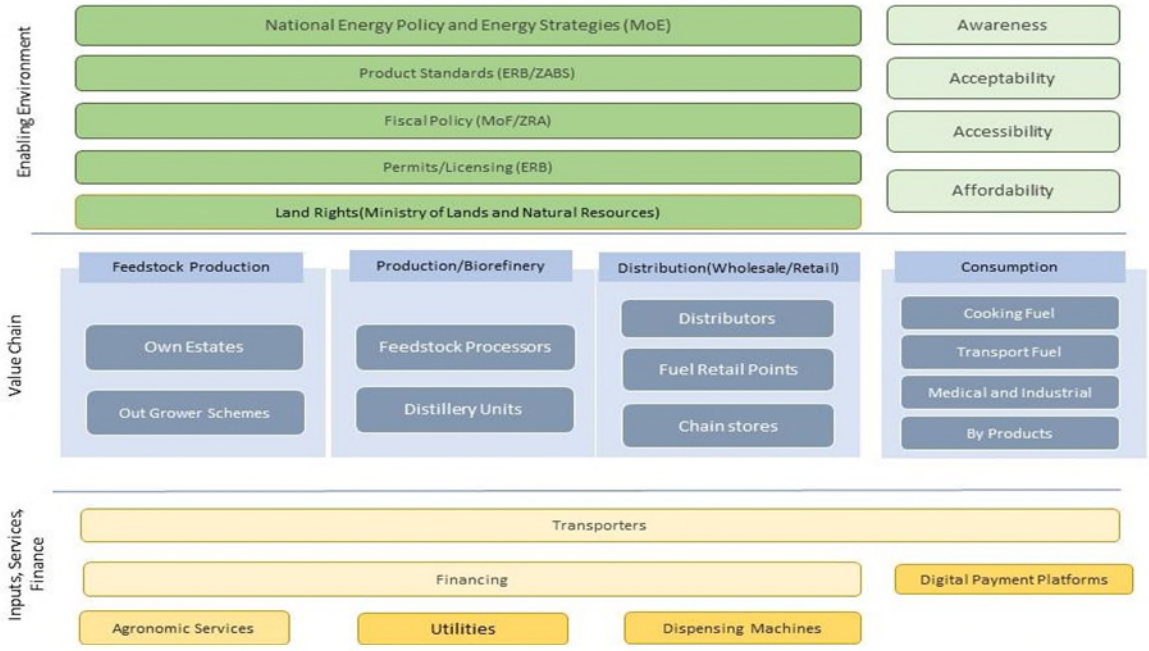


Figure 19 Ethanol Market System

VALUE CHAIN

Ethanol use for cooking in Zambia is still at a nascent stage, but there is significant potential to move households in urban areas away from solid fuels to ethanol. Shifting to ethanol cooking would provide Zambia with greater energy security, as opposed to LPG, which needs to be imported, while ethanol has zero impact on balance of payments and use of foreign currency. However, given the nascent status of the sector in Zambia, this section presents the limited existing initiatives alongside theoretical best practice, and estimations, to develop a picture of what an ethanol fuel cooking sector in Zambia might look like; along with the opportunities and barriers which must be taken account of if Zambia is to significantly shift towards ethanol as a cooking fuel. This section draws significantly from the Bioenergy and Food Security Assessment developed by the FAO which includes more in-depth analysis and context for interested stakeholders.

Feedstock Production

Two types of feedstocks are used in ethanol production, namely sugar and starchy feedstock. The first type of feedstock is rich in sugars such as sugar cane, sugar beet, and sweet sorghum. The second type includes options rich in starch such as maize, cassava, potatoes, and grain sorghum. The difference between the two feedstock types makes ethanol production from starchy feedstock slightly more complex. Both sugarcane and casava feature in the top five crops grown in Zambia by weight, as well as being in the top five crops for nutritional value (see table 16). Given their importance to nutritional value, care must be taken when making decisions about developing any future potential ethanol market; particularly for casava which is grown by smallholder farmers throughout the country.

Table 16: Top 5 Crops by Production Volume and Nutritional Value (adapted from the BEFS Assessment)

Crop	Production *(tons)*	Hectares	Yield	Food Supply *(kcal/cap/day)*	Percentage
Sugarcane	3,295,910	33,501	98.38	174	7.8
Maize	2,728,868	1,097,809	2.49	738	33
Cassava	1,580,794	135,283	11.69	504	23
Wheat	214,461	33,568	6.39	206	9.2
Soybean	200,231	118,632	1.69	168	7.5

Cassava is the second most important staple crop in Zambia after maize, and the third most produced crop with around 1.6 million tons generated every year. Cassava is a food security crop as it can be cultivated with low inputs and remain underground for long periods of time, to be harvested when needed by the household. However, cassava could be used as an ethanol feedstock. Due to its importance as a staple crop, as well as for the population's food security, special attention should be placed on the exclusive use of the additional production of cassava, after fulfilling existing needs for food, feed and other non-bioenergy uses.

Estimates for cassava show that through intensification an additional production of 1.12 million tons at the national level could be achieved each year, which could be used for ethanol production (see figure 20). At the district level the highest potential for additional production is in Samfya, Kawambwa, Nchelenge and Mansa districts in the Luapula province; Mungwi in the Northern Province and Mwinilunga in the North-Western Province. Each of these districts could reach an additional production above 60,000 tons per year. An important factor in cassava production is that it is carried out almost exclusively by small-scale farmers. Therefore, the possible inclusion of smallholders as a source of cassava feedstock for ethanol production could represent a secure and steady income for them. This could be accomplished by way of out-grower schemes and improved varieties and cultivation practices that could be promoted among smallholders, which would consequently improve yield production. However, given that casava is an important nutritional food security crop, and that any ethanol production would need to come from increased yields attained through intensification, it has been discounted from this market assessment. However, A2C would consider working with existing ethanol initiatives that plan to establish out grower schemes to increase production volumes of casava as an ethanol feedstock.

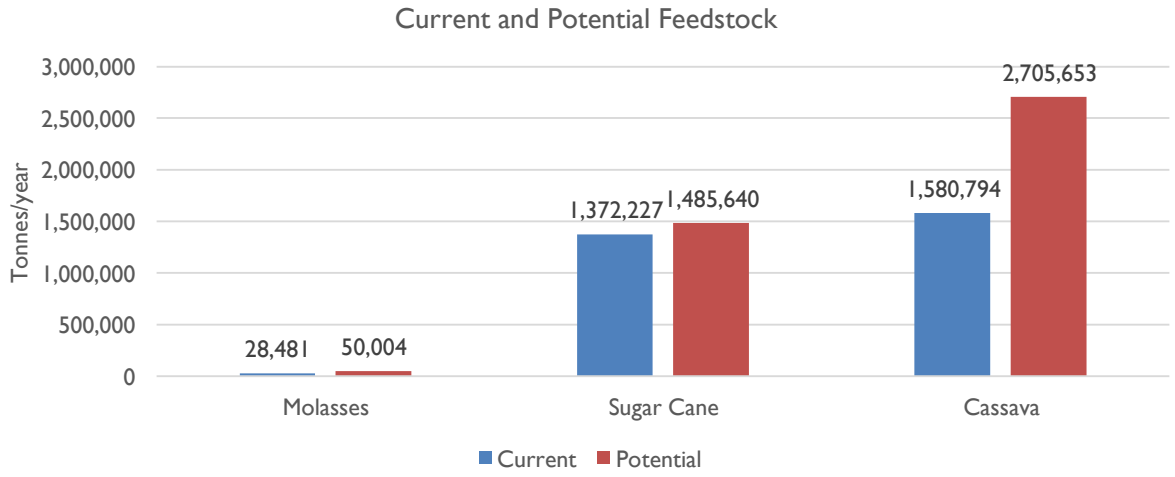


Figure 20 Current and Potential Feedstock Amounts

Sugar production is a high value agricultural industry with significant contribution to the manufacturing sector due to high value addition, diverse range of products and markets. The sugar market is largely private sector driven, highly concentrated and dominated by three sugar milling companies, namely Zambia Sugar Plc., Kafue Sugar and Kalungwishi Sugar. Sugarcane is currently the crop with the highest production volume in Zambia with an average annual production of 3 million tons. However, in terms of area coverage, the number of hectares devoted to sugarcane is relatively small compared to other crops with similar production volumes. The sugar transformation process results in refined sugar, raw sugar, specialty sugar products and molasses.

Ethanol can be produced from the sugarcane juice, as well as from molasses, a by-product of sugar production. Currently no company in Zambia is producing ethanol from molasses at a large scale. In terms of current use of molasses, it appears that, on average, 36 percent of molasses is sold on the local market and just over 43 percent is exported to neighboring countries; the remaining share is either used to coat dusty roads or is disposed of as waste. It has been estimated that there could be 113,412 tons of sugar cane juice and approximately 58,000 tons of molasses available annually to produce ethanol in Zambia, providing 9 million liters and 29 million liters respectively. However, estimates of sugar cane juice availability are based on intensifying farming practices to maximize sugarcane yields. Therefore, due to the additional investment needed, and the relatively limited volume of ethanol that could be produced, sugarcane juice has been ruled out as an option under this assessment. Therefore, the most viable, quick win, in the ethanol sector is likely to be ethanol production from existing molasses.

Refine

Once feedstock has been produced, it must be refined into ethanol. Large-scale national production of ethanol must be cost competitive with the imported alternative. The BEFS Assessment estimated that the CIF price of imported ethanol in Zambia would be USD 0.74 (see table 17). Therefore, any ethanol produced must have a factory gate price equal to, or lower than, this to make commercial sense.

Table 17: Landed Price of Liquid Fuels

	FOB Price (Rotterdam)	Ocean Freight, Insurance and Tanker Costs	Pipeline Costs	Total CIF Price
Diesel	0.48	0.26	0.05	0.79
Gasoline	0.43	0.24	0.04	0.71
Biodiesel	0.68	0.28	0.02	0.98
Ethanol	0.47	0.25	0.02	0.74

At the time of writing, only one company (Sunbird Bioenergy Zambia Limited) is intending to commence large-scale production of ethanol from casava feedstock for blending with petrol to meet the E10 mandate. Although not constructed yet, the plant is designed to produce 120 million liters of bioethanol per annum. Two more companies (Zhongkai International Company and Thomro Biofuels) are in the process of setting up commercial biorefineries in Central province using Cassava, sorg hum, and molasses as feedstock. There are also a few small-scale producers with less than 1 million liters annual production of ethanol from domestic waste and molasses. One such company is Kainos

Thomro Investments is an ethanol company based in Lusaka that secured an initial investment of $1 million to establish a micro-distillery capable of producing 91,250 liters annually (serving an estimated 4,345 households) from molasses and casava feedstock. However, investors eventually withdrew due to a lack of market readiness for ethanol cooking fuel and to date the plant is only producing 25 liters per hour. Thomro are currently constrained by a lack of investment to purchase the remaining equipment to fully operationalize their plant and establish a supply chain to transport the fuel to market. They intend to retail ethanol cooking fuel through existing charcoal sellers at a price of ZMW 19 per liter ($1.14) The company has been importing clean cookstoves from Durban, South Africa.

Green Energy, which produces ethanol specifically as cooking fuel in Lusaka and Copperbelt provinces.

Given that ethanol production from sugarcane juice and casava feedstocks have been discounted, as well as the nascent status of existing ethanol production, the remainder of this section focuses on the potential for ethanol from molasses, which is currently not being exploited for ethanol production. Utilization of molasses in Zambia would not require any additional investment in feedstock generation, as it is already produced as a by-product of the sugar refinery process. However, it would require the elimination of molasses exports to be re-purposed for national ethanol production. Indeed, it would make sense from a financial standpoint for a sugar mill to invest in ethanol production and give added value to molasses rather than sell them directly to the market.

The molasses-based process starts with the cutting and milling of sugarcane, which produces a juice with 10-15% solids from which sucrose is extracted. The bi-product of sugar production – molasses – is diluted and acidified and fed straight to the fermentation unit. The final steps are fermentation (converting glucose to ethanol), distillation and dehydration. Production through the molasses pathway requires the development of both the sugar industry and the ethanol industry. In fact, in Zambia it has been ascertained that the most viable option is for sugar refineries to diversify into ethanol production, rather than the establishment of independent ethanol producers who would need to purchase molasses from sugar companies. This is because stand-alone ethanol producers would need to purchase molasses from sugar factories at the going market rate (USD 126/ton), therefore increasing their production costs. However, sugar factories can simply divert their molasses away from the export market and instead transform it into a higher value good (ethanol), meaning they have lower ethanol production costs than an independent and standalone ethanol refinery.

Kainos Green Energy is a solar and ethanol company operating in Lusaka and Luanshya. They have established an operational distillery capable of producing 12,000 liters annually (serving an estimated 571 households) of 190 proof ethanol from molasses feedstock. They distribute their product through a small number of selected retail outlets, as well as offering deliveries for orders over 20 liters. As of 2021, one liter of ethanol is retailing at ZMW 15 ($0.9). The company is currently constrained by lack of storage space, inadequate transportation, and inability to access shelf space in supermarkets for their product. They have also been unable to access an ERB license as they produce below 2000 liters per day, which is contributing to their inability to access shelf space in supermarkets, as retailers are wary over the quality of their product. Kainos has trained two artisans to produce ethanol cookstoves (see image below) to sell to consumers.

Table 18: Ethanol Production from Molasses

Ethanol Production from Molasses	
Advantages	***Disadvantages***
- Allows for two industries and two revenue streams, ethanol and sugar - Reduces waste by-products i.e., molasses - Allows for use of bagasse to generate energy that can be used to fuel the plant and supply the national grid - Yield of sugarcane in Zambia is very high - Majority of molasses is currently exported or discarded as waste	- Supply of molasses is dependent on the sugar industry, which can result in shortages and price volatility if ethanol plants aren't integrated with sugar refineries - Current volumes of molasses limit production to 29 million liters of ethanol, and due to existing high yields, any additional sugarcane production would need to come from agricultural extensification

Table 19: Estimated Ethanol Plant Sizes and Ethanol Production Volumes from Molasses (adapted from the FAO BFES Assessment)

	Molasses (t/year)	Ethanol (million l/y)	Production Cost (USD/l)	Investment (million USD)
Min Viable	13,281	5	0.67	3.5
Min Expected	28,481	14	0.49	9.78
Max Expected	87,528	42	0.26	30.06
Average Expected	58,000	29	0.31	20.89

Based on the analysis by the FAO BEFS Assessment, the minimum viable production facility in Zambia would have an annual capacity of 5 million liters and a per liter ethanol production cost of USD 0.67. However, given the estimated available volume of molasses, Zambia could install a production facility of 29 million liters per year, at an anticipated ethanol production cost of 0.31 per liter and an initial investment of USD 20.89 million. Mazabuka district has been identified as a potential site for an ethanol production facility as this is where Zambia Sugar plc is located, which is Zambia's largest sugar producer.

Distribution and Retail

For ethanol as cooking fuel to reach the market several investments will be required at every stage of the distribution network. Firstly, distribution from the factory to the wholesale depot, then from the wholesale depot to the retail store and finally storage in the retail store. Building on estimates made in Kenya, and informed by the distribution model developed by KOKO, it is anticipated that a total investment of USD 1.9 million would be required in Zambia to develop the distribution network for 29 million liters annually, equating to an investment of USD 0.07 per liter. Of this investment, 4% (USD 79,708) would be required to establish smart depots, 33% (USD 628,366) is needed for small tankers to transport the fuel and 63% (USD 1,207,578) would be directed towards retail dispensaries. However, it must be noted that these estimations are based on recreating a model like KOKOs which establishes hi-tech ATM type ethanol dispensaries at strategic locations throughout an urban area.

Table 20: Estimated Investment to Establish Ethanol Distribution Channel (adapted from the Kenyan Ethanol Market Assessment)

Distribution Investment	Kenya	Zambia	Share %
Annual Production (liters)	192,000,000	29,000,000	-
Total Investment (USD)	12,682,935	1,915,652	-
Smart Depots	60,000,000	79,708	4%
Small Tankers	473,000,000	628,366	33%
Retail Dispensers	909,000,000	1,207,578	63%
Investment (USD/l)	0.07	0.07	-

It is likely that a simpler approach to retailing ethanol could reduce costs at this point in the distribution network. Investment in storage (for strategic stocks) and bottling plants would be needed. Additional aspects would include fuel truck off-loading infrastructure, fuel quality testing laboratory, batch mixing to the correct specifications and denaturing, then a bottling line that will handle the expected sales volumes. Bulk distribution in Zambia is mostly done through large distribution companies. In total there are more than 50 distribution companies for Fast Moving Consumer Goods (FMCG) in Zambia with leading companies such as Trade Kings, Panafrica Distributors Ltd, Unity Distributors Ltd and L & A Distributors.

Figure 21 Depiction of Ethanol Supply Chain

Trade Kings, for example, has already demonstrated an initial interest in entering the ethanol cooking fuel market after seeing A2C communications material.

In terms of retail price for ethanol on the Zambian market, information from other ethanol suppliers, Koko in Nairobi and Consumers Choice limited Dar es Salaam, indicates fuel sales prices of $0.70 to 0.73/liter (excluding VAT). A sales price of this level is built up from a distiller/producer factory gate price, currently estimated at $0.4/liter. Therefore, a mark-up of around $0.33/liter is needed to cover bottling, distribution, and sales margins. From a Zambian perspective, a slightly lower distiller price is estimated at $0.37, plus a higher distribution and retail markup is assumed, as the businesses are likely to be smaller, with higher overheads, estimated at $0.4/liter price. This equates to a selling price (excluding VAT) of $0.77/liter and $0.99 with VAT. Currently, ethanol gel fuel is retailing at $2.10 (ZMW 35) for 750ml, equating to $2.80 per liter. While existing small scale ethanol producers in Zambia are retailing liquid ethanol at $0.9 per liter.

Features, benefits and competitive advantages of ethanol stoves:

- Powerful burners, >1.4kW, fully comparable with modern LPG or electric cookers.
- Completely clean burning so cooking can take place in the house, not isolated outside.
- Highly attractive stove, either single or double plate can be offered.
- Stoves can be easily and safely operated, with simple filling and lighting, no spillage or danger of pressurizing and explosion.
- Storage of fuel is clean, practical, safe and economical.

Ethanol stoves (see table 21) available in Zambia are imported through South Africa. Three brands are currently on the market, Clean Cook, Alva and Quality Common, which are being sold in supermarkets and chain stores owned by South African companies, such as Game and Shoprite. Typically, these products are marketed and aimed at the outdoor and camping sectors, with products displayed alongside camping goods, rather than in the kitchen and homeware departments of stores. Shoprite is the leading retailer for both ethanol stoves and fuels in Zambia. With 40 supermarkets in Zambia, Shoprite opened its first supermarket in 1995 and has expanded throughout the country over the last 25 years. Other retailers include Pick and Pay (23 stores) and Game Stores (3).

Table 21: Ethanol Stoves

Product		
Two Burner Gel Fuel		Brand: Quality Price: ZMW 250
Two Burner Liquid Fuel		Brand: CleanCook Price: ZMW 250
Two burner Liquid Fuel		Brand: Kainos (locally produced) Price: ZMW 120

Consume

While the focus of this report is on the utilization of ethanol for cooking, it must be noted that there are several competing consumer segments for ethanol, including medical and transport. Of particular relevance is the transport sector. The Government of the Republic of Zambia aspires to blend petrol with ethanol to meet its E10 mandate. To achieve this, Zambia must produce 72 million liters of ethanol annually. Should GRZ move ahead with these plans, it would represent significant competition to ethanol-based cooking, especially as ethanol producers would be assured of a market for their product and a guaranteed price, tied to the price of petrol.

Currently, ethanol use for cooking is virtually non-existent in Zambia and it does not feature as a cooking fuel reported by households in the Living Conditions Monitoring Survey (2015), or the Consumer Preference Study conducted by A2C (2021). However, estimates of household consumption of ethanol in sub-Saharan Africa vary from 6 liters per month for preparing beverages and other quick cooking needs (based on a fuel stacking scenario) through to 15 and 35 liters a month if a full shift to ethanol cooking is realized. Therefore, on average, households could consume approximately 22 liters of ethanol each month, totaling 258 liters annually. Based on the assumed ethanol production potential of 29 million liters in Zambia, this equates to 112,403 households that could switch to ethanol-based cooking. In 2015, the Living Conditions Monitoring Survey estimated that there were 166,580 medium cost households in Zambia, meaning that ethanol could be the cooking fuel of choice for two thirds of this income group, who are typically located in the major urban centers. At an estimated retail price of $0.77 per liter, the average monthly household expenditure would be $17, or ZMW 274.

Outside of ethanol sales, additional income can be realized from selling by-products such as DDGS for animal feed production. This by product is found when producing ethanol from maize or cassava. DDGS are nutrient rich co-product of dry-milled ethanol production containing approximately 29% crude protein, 10% fat, 9% crude fiber and 5% ash. Current demand for livestock feed materials, such as soyabeans, sunflower and cotton are on its peak with prices ranging from K10-k22 per kilogram. For every 1 liter of ethanol fuel produced, 3 kgs of distillery waste is generated. A 5 million liter per year plant will have 15 million kilograms of distillery waste with monetary value of not less than 75million Zambian kwacha if sold at a rate of K5/kg.

INPUTS, SERVICES AND FINANCE

Electricity: An additional critical factor for ethanol production is energy management, due to the massive thermal energy consumption that occurs throughout the process. Modern ethanol factories include energy self-generation solutions such as cogeneration systems. During the sugar juice extraction process, the factory produces bagasse as a by-product that can be used in a combined heat and power (CHP) system to cover the demand for electricity and heat in the factory. The eventual electricity surplus can then be sold to the national grid. Based on BEFS assessment it is evident how initially, without CHP systems, most of the production costs would be higher than the ethanol comparison price. This situation changes once the effect of CHP systems is implemented, due to the benefits obtained from energy savings and credits from potential electricity sales. These savings and credits in turn deduct the energy demand share from the costs shares. For this reason, energy management should be considered a critical factor for the future development of ethanol production in Zambia.

Finance: Given the nascent status of the ethanol sector in Zambia, significant investment is needed throughout the value chain. Under this market assessment we have discounted casava and sugarcane juice as ethanol feedstock options due to the additional investment required to either intensify, or extend, farming practices to produce enough feedstock for ethanol production. However, investment is still needed at the refinery, distribution, and retail stages of the value chain, for both ethanol fuel and stoves.

At the refinery stage, to establish a large-scale ethanol plant capable of producing 29 million liters a year from molasses, an investment in the region of $20.89 million is required. Based on estimates from Kenya, and based on the KOKO model, an investment in the region of $1.9 million is needed for the establishment of depots, procurement of small tankers and the installation of retail points. However, as noted previously, these costs may be lower if a less hi-tech approach is taken in Zambia. Alongside the distribution network it would be critically important to factor in 3 months strategic fuel stock in case of shortages. For a market of 112,403 households, consuming 21 liters each per month, this would equate to 7,250,000 liters held in reserve. At a factory gate price of $0.37 per liter this amounts to $2.7 million tied up in working capital for ethanol reserves. Finally, the working capital needs of stove retailers would be in the region of $600,000 based on them placing a minimum order of 20,000 stoves at $30 per stove. In terms of consumer financing, the major barrier relates to stoves, as opposed to the fuel, as the fuel can be purchased in small, more flexible quantities. Consumer financing for stoves can be in form of payment methods such as layby and payment in instalments; or subsidized through Results Based Finance type modalities, or alternatively carbon finance revenues.

ENABLING ENVIRONMENT

The National Energy Policy (2019) only covers biofuels from the perspective of the transport sector. The aim is to augment petroleum supply through the promotion of biofuels such as ethanol. The Ministry of Energy, through the Energy Regulation Board, is responsible for regulating the biofuel sector. As such ERB issued standards ZS E100 (for bioethanol) and ZS B100 (for biodiesel) in May 2008 and has put in place a biofuels framework with specific licenses for production/refining, storage facility, blending facility, distribution, and retail. This targeted blending mandate aims to achieve a blend of ethanol with gasoline and biodiesel with diesel in shares of 10 and 5 percent, respectively, by 2030, with a view to reducing the petroleum import bill. It is estimated that Zambia needs 72 million liters of ethanol to meet its E10 mandate. However, these standards focus on regulating biofuels for blending with petroleum products to be used in the transport sector and not as a cooking fuel. If a shift to ethanol cooking was to be advanced, specific standards would likely need to be developed as they currently do not exist. Similarly, no national targets exist for ethanol as a cooking fuel and would need to be developed.

Within the existing biofuels regulations, the ERB sets out the following requirements for obtaining a license to establish an ethanol plant in Zambia:

- 5 years (for first time applicants) or 3 years (for renewals) Business plan
- Latest audited financial statements (if business is already Operational)
- Latest annual returns from PACRA
- Certificate of incorporation
- Proof of funds, i.e., six months bank statement or Documentation showing commitment from sponsor (s) with Board resolution
- List of shareholders and directors from PACRA
- Certified copies of national registration cards (NRC) or Passports of Directors
- Detailed process flow diagram of biofuels production and or blending facility
- Detailed engineering/technical drawings of production and or blending facility
- Certified third party product analysis reports for biofuel Produced from the production and or blending plant for Three full capacity batches
- Latest tax clearance certificate from ZRA.
- Residence permits for foreign directors/shareholders

In terms of tax status, cooking appliances for liquid fuels, such as ethanol, are currently zero rated for import duty and VAT, while excise duty does not apply (see table 22). Unfortunately, we were unable to verify the tax status of gel and liquid ethanol fuel with ZRA.

Table 22: VAT and Duty Status for Ethanol

Ethanol	HS Code	Description	Import Duty	Excise	VAT
Cooking Fuel					
Stoves	7321.12.00	Cooking appliance and plate warmers: For liquid fuel	0%	N/A	0%

Biofuels Association of Zambia is an association of firms, companies and individuals involved and/or planning to be involved in the production of feedstock and/or biofuels in Zambia. The association was formed in 2006 with the support from the Department of Energy. It is a lead industry association in the promotion of the production and use of biofuels in Zambia, in accordance with quality and social standards, and economically-sound production principles.

Objectives and Functions of the Association:

- To promote and foster the production, distribution, sale, and consumption of biofuels in Zambia.
- To support research and development in biofuels to improve the delivery efficiency of the industry.
- To promote and foster reduction of the unit cost of production for players in the supply chain for biofuels.
- To promote and foster the cooperation between the biofuels and the mineral energy industries.
- To promote and foster the dissemination of information to, from and between its members, and other stakeholders.
- To promote and foster the interests of its members amongst non-affiliated, non-government and government institutions.
- To remain non-political without any affiliations or connections, direct or indirect

7.2 EMERGING MARKET DEVELOPMENTS AND INNOVATIONS

KOKO Networks has built technology to transform the market for urban cooking fuel. KOKO retails a modern, high-power Cooker, which comes with a reusable bottle that is linked to a customer through their mobile phone number. The KOKO Cooker retails for around 40 US dollars, and customers can use their KOKO account to save towards the total amount over time. The fuel itself is significantly cheaper than deforestation-based charcoal or kerosene. A large part of the fuel affordability stems from the removal of expensive single-use plastic bottles. To date, this is Africa's largest deployment of Internet of Things (IoT) technology for consumer fuels, with cloud-based tracking of fuel inventory across the supply chain: each "KOKO Point" is connected to the "KOKO Cloud" software platform, sending real-time updates – via a range of internal sensors – to a Network Operations Centre. At the same time, KOKO's fuel distribution partner Vivo Energy Kenya sources molasses-based bioethanol fuel from local and regional suppliers and delivers it to selected service stations it operates across Nairobi. These service stations have dedicated underground storage tanks for holding cooking fuel, with KOKO's customized IoT hardware controlling the movement and tracking of fuel, first onto small fuel delivery trucks, and then during the last-mile distribution to the Fuel ATMs.

7.3 BARRIERS AND SUPPORTING INTERVENTIONS

Table 23: Ethanol Barriers and Supporting Interventions

Market System Issue	Support Intervention
Enabling Environment	
Policy: Currently national energy policies and strategies focus on ethanol for blending with petrol to meet the E10 mandates; ethanol does not feature as a cooking fuel option.	Technical Assistance: A2C should work with GRZ and development partners to develop a Clean Cooking Strategy which clearly set's out a pathway to achieving universal access to clean cooking by 2030, including the role ethanol cooking can play in the energy mix.
Regulatory: Existing regulations focus on blending ethanol with petrol to meet the E10 mandate, but do not specifically focus on ethanol as a cooking fuel.	Technical Assistance: A2C should support GRZ to review existing regulations, identify gaps and propose new regulations which meet the needs of the ethanol cooking fuel sector.
Regulatory: Currently ERB does not have a biofuels testing laboratory to ensure quality standards are achieved.	Technical Assistance: A2C should work with ERB to determine their resource and funding needs for a biofuels testing laboratory. However, direct financial assistance is out of scope for the A2C project.
Accessibility: Currently ethanol is only available in a limited number of supermarkets and often positioned in the outdoor/camping departments.	Technical Assistance: As local distribution and retail channels are developed, A2C, through its SBCC campaign, should communicate to consumers where they can purchase ethanol cooking fuel.
Awareness and Acceptability: Ethanol use as a cooking fuel is practically non-existent in Zambia, with consumers unaware of the option and how it can meet their household cooking needs.	Technical Assistance: Through its SBCC campaign A2C should work with key stakeholders to build the profile of ethanol as a cooking fuel, educating consumers to better understand its utility as a household cooking fuel.
Value Chain	
Feedstock Production: Currently, the most viable "quick win" for ethanol production is using molasses feedstock from existing sugar production. While 21% of molasses is disposed of as waste, this is will not produce sufficient ethanol for a transformative shift to ethanol-based cooking. However, 43% is exported to markets outside of Zambia.	Technical Assistance: A2C should engage sugar refineries to develop and test the business case for re-directing molasses away from the export market and into ethanol production.
Refine: No large-scale ethanol refineries are operational in Zambia, creating a significant barrier to scaling the sector. However, ethanol production from molasses has been identified as the quickest win. But to keep factory gate prices as low as possible, sugar refineries need to diversify into ethanol production.	Technical Assistance: Support sugar refineries to develop detailed feasibility studies for establishing ethanol production plants.
Distribute: Distribution channels for locally produced ethanol cooking fuel do not currently exist and would need to be established to ensure the product can reach the market.	Technical Assistance: A2C should support the development of a detailed distribution strategy based on the estimated market size in Zambia. Levels of investment should be determined, based on the required infrastructure needs of the market.
Retail: While estimates of final retail price have been made, and appear positive, a more precise calculation of cost to the consumer needs to be determined to inform	Technical Assistance: A2C should develop a detailed financial model for ethanol cooking fuel which determines an accurate retail price based on different scenarios. Based on this, A2C will be able

likelihood of large-scale adoption and potential market size.	to more accurately estimated the potential market size.
Inputs, Services, Finance	
Business Finance: Given the nascent status of the ethanol cooking sector in Zambia, significant investment is needed to reach scale. In total it is estimated that $26.09 million would be needed to provide 29 million liters annually, serving 112,403 households.	Technical Assistance: A2C should work with companies in the ethanol value chain to identify sources of investment. This could include acting as match maker between suitable companies and investors. Technical Assistance: Working with development partners, support Zambia and the ethanol fuel sector to unlock climate finance. The Norwegian Carbon Procurement Facility (NorCaP), Swedish Energy Agency (SEA), the World Bank (with their Carbon Initiative for Development program), the Green Climate Fund (GCF), and the Global Environment Facility (GEF) are deploying finance globally towards projects that promote energy efficiency and low carbon emissions, which ethanol cooking fuel projects could benefit from. Financial Assistance: Through its grant facility, A2C could support existing smaller scale initiatives, helping them to overcome barriers to operationalizing micro-refineries and establishing routes to market.

8. ATF AFFORDABILITY AND CONSUMER FINANCING

Building from the methodology in the NEFCO BGFA Clean Cooking Solutions Market Scoping Report we analyzed the theoretical affordability for ATF products in Zambia to estimate the potential addressable market for our target ATFs. The main variable used to define theoretical affordability is the upfront cost of ATF products relative to monthly household cooking fuel expenditure. While consumers may realize cost saving opportunities from ATF adoption over time, their biggest barrier to entry is the upfront cost of the stove as households with limited disposable income most often prioritize short-term needs over long-term benefits such health and cost savings. The table below sets out the methodological steps for the analysis; due to data limitations, fuel stacking was not included in this analysis, and we assumed that households spend their entire disposable income to purchase one ATF product.

Table 24: Steps for ATF Affordability Assessment and Market Size

Step	Source/Proxy and Data
Identified actual number of households in 2020	UN Population Data, 2020
Identified monthly household expenditure per quintile (2021) and estimated household monthly fuel expenditure by quintile (2021).	- Income: ZamStats Socio-Economic Impact of COVID-19 Report (2021) - Fuel Expenditure: USAID, A2C Consumer Preference Study (2021) o Quintiles 1 & 2: 20% o Quintiles 3, 4 & 5: 10% *See Figure 22*
Conducted secondary research to obtain prices of various ATF products On the Zambian market. LPG costs were calculated based on the lowest cost stove, cylinder and fuel combination for each product range	A2C data collection from online stores and in store visits (September 2021) *See Figure 23*
Calculated ATF affordability ranges for each income quintile, based on:	A2C Analysis - Immediate Purchase if the upfront cost of an ATF product is equal to or less than the household's assumed baseline monthly cooking expenditure. - Save to Purchase if the upfront cost of a ATF product is equal to or less than a household's 3 months' cooking expenditure (assuming a household would save for 3 months to purchase) - Finance to Purchase if the upfront cost of an ATF product is equal to or less than a households 6 months cooking expenditure (assuming low, or no interest financing) - Unaffordable for a household if the upfront cost of an ATF product is greater than 6 months' cooking expenditure *See Table 25*
Analyzed theoretical affordability estimating the number of households in Zambia able to afford each product type.	A2C Analysis *See Figure 24*

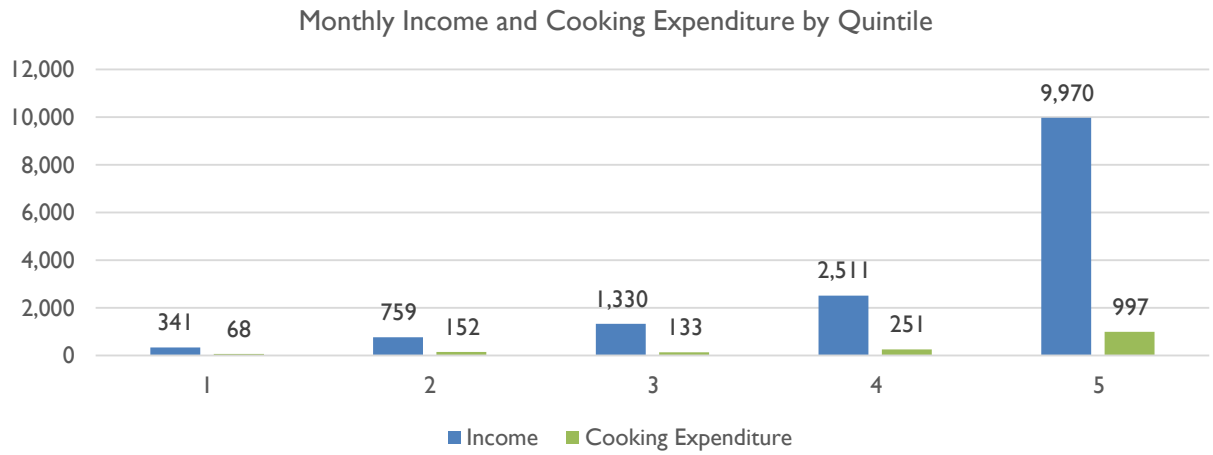


Figure 22 Monthly Income and Cooking Expenditures by Quintile

Figure 23 ATF Market Prices

At the quintile level, the first quintile can afford the two-plate electric hotplate, double liquid ethanol stove and the double ethanol gel stove, but they would require financing. The second and third quintiles could afford to purchase the two-plate electric hotplate, double liquid ethanol stove and the double ethanol gel stove if they saved for three months, or the single LPG burner on financing. The fourth quintile could just about purchase the two-plate electric hotplate, double liquid ethanol stove and the double ethanol gel stove immediately, can almost afford the single LPG burner after saving for three months and could afford the two-plate electric oven, the two burner LPG stove, or the electric pressure cooker if financing was available. The fifth quintile can purchase the two-plate electric hotplate, double liquid ethanol stove, double ethanol gel stove and LPG single burner immediately, while they would need to save for the two-plate electric oven, the two burner LPG stove, gasifier stove or the electric pressure

cooker. Finally, the fifth quintile could also afford the larger appliances with ovens, if financing was available.

Table 25: ATF Affordability Brackets by Income Quintile

ATF Affordability			
Quintile	Immediate Purchase	Save to Purchase	Finance to Purchase
1	ZMW 68	ZMW 205	ZMW 409
2	ZMW 152	ZMW 455	ZMW 911
3	ZMW 133	ZMW 399	ZMW 798
4	ZMW 251	ZMW 753	ZMW 1,507
5	ZMW 997	ZMW 2,991	ZMW 5,982

Two plate electric hotplates, ethanol gel stoves and double ethanol liquid stoves are the most affordable options on the market, with 1.5 million households being able to purchase one immediately using their estimated monthly cooking fuel expenditure, a further 1.5 million households could potentially purchase these if they save for 3 months, while the remaining 0.7 million households would require consumer financing. However, it must be noted for electrical appliances, these analyses do not account for electricity connection rates. Therefore, while a household could afford the appliance, they may not have the means to power it. As noted earlier, based on the Living Condition Monitoring Survey (2015) 67% of urban households, and 71% of households in Lusaka, have an electricity connection. As such, estimated market sizes could be adjusted based on these connections rates to arrive at a more representative market size.

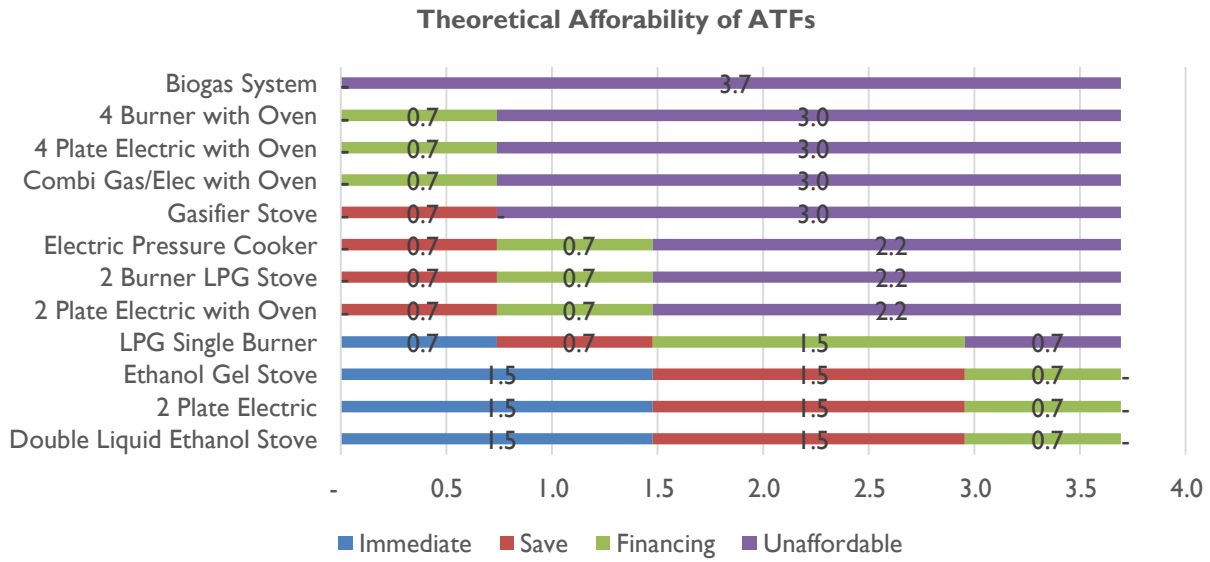


Figure 24 Theoretical Market Size for ATFs

LPG single burners are the most affordable LPG appliance, with 0.7 million households able to purchase one immediately, 0.7 million could potentially save and purchase one, 1.5 million households would require financing and 0.7 million would not be able to afford one at all. Two plate electric cooker with oven, two burner LPG stove, and the electric pressure cooker all followed the same pattern, as they are at similar price points. For these appliances, 0.7 million households would need to save, 0.7 million would require financing and 2.2 million could not afford them, unless longer financing options were available. Due to its price point, and the short financing terms used in this analysis, the gasifier stove is

only affordable to 0.7 million households, based on saving for three months. However, the main gasifier stove supplier in Zambia is currently offering attractive financing terms of 35 months to make the stove more affordable, which increases the potential addressable market. At the top end of the market, the LPG four burner with oven, the four-burner combi gas/electric with oven and the four-plate electric with oven all also followed the same pattern. Due to their high cost, they were only affordable to 0.7 million households based on financing, while these appliances were unaffordable to the remaining 3.7 million households. Finally, biogas systems are unaffordable to all households, unless financing options longer than 6 months are available.

The above analysis focuses on upfront appliance affordability and does not factor in the comparative cost of cooking using different fuel-appliance combinations. Neither does it estimate a lifetime cost of cooking. However, the MECS Kitchen Laboratory study determined the cost of cooking for several dishes on an EPC, electric hotplate, LPG stove and charcoal mbaula. For all dishes, cooking with the electric devices incurred lower cost than the charcoal mbaula, with the EPC being the lowest cost of the two electrical appliances. For all but one dish the LPG stove was more cost effective than the charcoal mbaula, but more costly than the electrical appliances. The USAID funded CEADIR Cost Benefit Analysis of cooking options in Zambia (table 26) determined that electric hotplate had the lowest lifetime financial costs to households, followed by the efficient EcoZoom charcoal cookstove, the charcoal mbaula, LPG stove and finally the ethanol gel stove. Therefore, it appears that not only does electric cooking on a hotplate represent the lowest upfront financial barrier to households, but it also represents the lowest lifetime cost. LPG represents a higher upfront cost barrier and a higher lifetime cost. While ethanol gel fuel stoves have a relatively affordable upfront cost, they represent the costliest lifetime option, presumably due to the higher cost of the fuel.

Table 26: Lifetime Financial Cost to Households (Source: CEADIR Cost Benefit Analysis)

Stoves and Fuels	Discounted Financial Costs per Household		
	3 Percent Discount Rate	7 Percent Discount Rate	12 Percent Discount Rate
Ethanol gel stove	$3,842	$3,164	$2,547
Liquefied petroleum gas stove	$3,063	$2,529	$2,041
Improved Mbaula charcoal stove (H)	$1,707	$1,406	$1,132
Traditional Mbaula charcoal stove (H)	$1,505	$1,239	$997
EcoZoom Jet charcoal stove (H)	$934	$769	$620
Single-burner electric hotplate	$507	$418	$337

9. CONSUMER PROFILES

Through the A2C Consumer Preference Study we defined three consumer segments for Lusaka, based on low (<ZMW 1,000), medium (ZMW 1,000 – 3,000) and high (>ZMW 3,000) income households. The first income quintile is predominantly made up of rural households and does not align with our urban consumers segments. Low-income households broadly relate to income quintiles 2 and 3, while medium income households align with income quintile 4 and high income households align with income quintile 5. The tables below set out the profiles for each consumer segment, presenting a snapshot of current practices, knowledge, and aspirations.

Table 27: A2C Consumer Profiles, by Quintile

High Income Segment / 5th Quintile	
Demographics	6 people / household, married, well educated, formally employed (>3000/month)
Fuel Knowledge	High for electricity, LPG, charcoal and firewood; moderate for pellets and briquettes
Fuel most used	Charcoal
Fuel stacking	Mainly electricity and charcoal (69%), charcoal only (11%)
Fuel Expenditure*	Electricity ZMW 355, LPG ZMW 350, firewood ZMW 80, charcoal ZMW 276
Fuel Aspirations	39% electricity (faster, easy to use, modern) and 36% LPG (affordable, faster, not smokey)
Appliance knowledge	High for electrical appliances including efficient devices, moderate for LPG devices
Appliance most used	Traditional Mbaula (42%)
Appliance Aspirations	Electric cooker with oven (32%), LPG Cooker (25%), improved charcoal stove (10%)
Improved cookstove	27% already own, 64% would buy, paying between 120 – 165, preferably in cash
Access to info	Predominantly receiving info from friends, neighbors and relatives, as well as TV
Middle Income Segment / 4th Quintile	
Demographics	6 people / household, married, secondary education, self-employed (1000 - 3000/month)
Fuel Knowledge	High for electricity, LPG, charcoal and firewood; moderate for solar and paraffin
Fuel most used	Charcoal
Fuel stacking	Electricity and charcoal (40%), charcoal only (30%)
Fuel Expenditure*	Electricity ZMW 210, LPG ZMW 175, firewood ZMW 150, charcoal ZMW 207
Fuel Aspirations	53% electricity (faster, easy to use, modern) and 26% LPG (clean, faster, not smokey)
Appliance knowledge	High for electrical appliances, moderate for LPG as well as efficient devices
Appliance most used	Traditional Mbaula (67%)
Appliance Aspirations	Electric cooker with oven (34%), LPG Cooker (10%), LPG Hotplate (10%)
Improved cookstove	24% already own, 66% would buy, paying between ZMW 95 – 145, preferably in cash
Access to info	Predominantly receiving info from friends, neighbors and relatives, as well as TV
Low Income Segment / 2nd and 3rd Quintiles	
Demographics	6 people / household, married, primary education, self-employed (<1000/month)
Fuel Knowledge	High for electricity, charcoal and firewood; moderate for LPG, solar and paraffin
Fuel most used	Charcoal

Fuel stacking	Charcoal only (45%), firewood and charcoal (25%), electricity and charcoal (18%)
Fuel Expenditure*	Electricity ZMW 210, firewood ZMW 150, charcoal ZMW 194
Fuel Aspirations	62% electricity (faster, easy to use, clean) and 16% LPG (clean, faster, modern)
Appliance knowledge	High for electrical devices & charcoal ICS, low for LPG & efficient devices
Appliance most used	Traditional Mbaula (80%)
Appliance Aspirations	Electric cooker with oven (36%), electric hotplate (13%)
Improved cookstove	22% already own, 74% would buy, paying between ZMW 75 – 120, preferably in cash
Access to info	Predominantly receiving info from friends, neighbors and relatives, as well as TV

10. BUSINESS FINANCING & INVESTMENT

10.1 FINANCING NEEDS, TYPES AND BARRIERS

Funding needed to achieve universal access to modern energy cooking services by 2030 is estimated to be $150 billion annually, however only $70 million was raised in 2019 by the 25 clean cooking companies tracked by the Clean Cooking Alliance (Cogan, Otieno, & Weston, Clean Cooking: Scaling Up with Crowdfunding, 2021). In order to grow the impact that clean cooking stoves and alternative technology fuels can have on poverty reduction and health outcomes within Zambia, ATF companies need access to funding and investment that allows them to scale their operations. Without access to funding to support organizational overhead, sales operations, and working capital requirements, ATF companies will quickly encounter challenges in maintaining their operations.

There are three categories that financing falls into: equity, debt, and non-dilutive. Equity financing is capital invested into a firm without a specified repayment date, but instead is used to purchase a portion of ownership of the ATF company (Powering Agriculture, 2020). Debt financing is a financing method involving an interest-bearing instrument, usually a loan, the payment of which is only indirectly related to the sales and profits of the ATF company. Debt financing typically requires a portion of assets owned by the ATF company to be used as collateral to protect the lender in case of loss (Powering Agriculture, 2020). **Error! Reference source not found.** shows the different kinds of investment that ATF companies could access. Non-dilutive financing refers to any capital a business owner receives that does not require them to give up equity or ownership. Examples include contributions from donors, vouchers, grants and even family

Table 28: Financing Types Available

Equity	Friends & Family Investment	When entrepreneurs draw on their own resources or their personal relationships to identify investors that are willing to provide funding in exchange for a portion of company ownership.
	Angel Investors	High net worth individuals that invests their personal funds into companies in exchange for a portion of ownership of the company (equity) or a repayment of funds with a suitable return (debt).
	Venture Capital Funds	Professionally managed pools of money designed to invest in startups for a significant return on investment. Micro VC Funds represent a subset of traditional VC funds that invest smaller amounts of money into earlier stage companies. They fill an ever-widening funding gap left by traditional VCs who increasingly prefer larger deals with more mature, revenue-generating companies.
Debt	Commercial Lenders	Include local, regional, or international banks or debt funds that provide short-term loans provided that the applicant can provide suitable collateral.
	Donor Lenders	Can provide debt without the need for collateral or at below-market interest rates. Donors can also increase the supply of commercial lending through the use of first loss guarantees or subsidizing lending transaction costs to facilitate small loan amounts (Powering Agriculture, 2020).
	Trade Credit	Form of debt financing which allows an organization to delay payment for goods and services after they have been delivered or provided as a result of an agreement between the supplier and firm. Trade credit is one of the most important forms of external financing available to SMEs, which an estimated one-third of all debt extended to SMEs coming in the form of short-term trade credit. (Garcia-Terieul & Martinez-Solano, 2010)
	Revenue-based Financing	An investment structure that is gaining popularity with angel investors and accelerators. It allows for investors to receive a fraction of company revenue

		until a pre-determined amount, including a suitable return on capital, is repaid to the investor.
Non-dilutive	Grants	Capital provided by a philanthropy, government, or corporate social responsibility initiative to achieve specific milestones or advance the mission of the grant provider. It is important to note that private sector investors have a diverging view of grant funding. Investors see grant funding as a non-market-based distraction to eliminating market and technology risks. Most private investors do not view grants as evidence that they should invest in a company, and in some cases, it can be a red flag.
	Carbon Financing	Sale of verified carbon offsets produced by ATF companies to purchasers who wish to offset their own GHG emissions. These can fall into the compliance (CDM) or voluntary (GS, VCS) markets.
	Crowdfunding	Method of raising small amounts of equity, debt, or grant capital from a large number of people through an online platform. (Cogan, Otieno, & Weston, Clean Cooking: Scaling Up with Crowdfunding, 2021)

Interviews with investors targeting energy access companies conducted by the Powering Agriculture Energy Grand Challenge found that investor fatigue, a sector-wide lack of investment readiness, and general misalignment of profit motives were barriers to securing investment (Powering Agriculture, 2020). A lack of profitable exits in the energy access industry has taught investors that clean energy is a difficult industry to make money in. This wariness has transformed into investor fatigue and impacts investors' current willingness to invest money into ATFs. Investors also highlighted that clean energy entrepreneurs generally lack investment readiness and the business experience necessary to convince investors that companies will be grown to profitability. Finally, investors highlighted that many clean energy companies that approached them for investment were not obviously motivated in making a profit from selling their product. This is problematic for investors because companies need to make a profit for investors to make money on them.

10.2 COMMERCIAL DEBT LENDERS IN ZAMBIA

In 2019 the formal Zambian credit market comprised of 61 credit services providers in the banking and non-banking financial institution sectors; including 19 banks (table below) and 42 credit providers in the NBFI sector. In 2019, the credit market posted a 20.4% increase in total credit issued over the previous year. However, while the level of credit increased, it remained below the Sub-Saharan average.

AB Bank Zambia	Citi Bank	Stanbic Bank Zambia Limited
Amalgamated Banks of South Africa (ABSA)	Ecobank Zambia Limited	Standard Chartered Bank Plc
Access Bank	First Alliance Bank Limited	United Bank for Africa Zambia Limited
African Banking Corporation Zambia Limited	First Capital Bank Zambia	Zambia Industrial Commercial Bank Plc
Atlasmara	First National Bank Zambia Limited	Zambia National Commercial Bank Plc (ZANACO)
Bank of China	Indo – Zambia Bank Limited	
Cavmont Bank	Investrust Bank Plc	

Figure 25 Commercial Lenders in Zambia

The Credit Market Monitoring Report (2020) issued by the Bank of Zambia presents an overview of Zambia's credit market, the objective is to provide market stakeholders with aggregated credit data to promote market development. Unsurprisingly, the report indicates that banks provided the largest share of loans in 2019 by value (kwacha) at 84% of the total credit market, followed by MFIs (8%). The majority of loans issued were backed by assets (40%), followed by mortgages (18%), while 27% of the total loan value was issued as unsecured loans. Most of these loans were made to the large business sector (33%), followed by the Government of the Republic of Zambia (27%), with micro-small-and-medium-enterprises (MSMEs) only receiving 9% of loans by value.

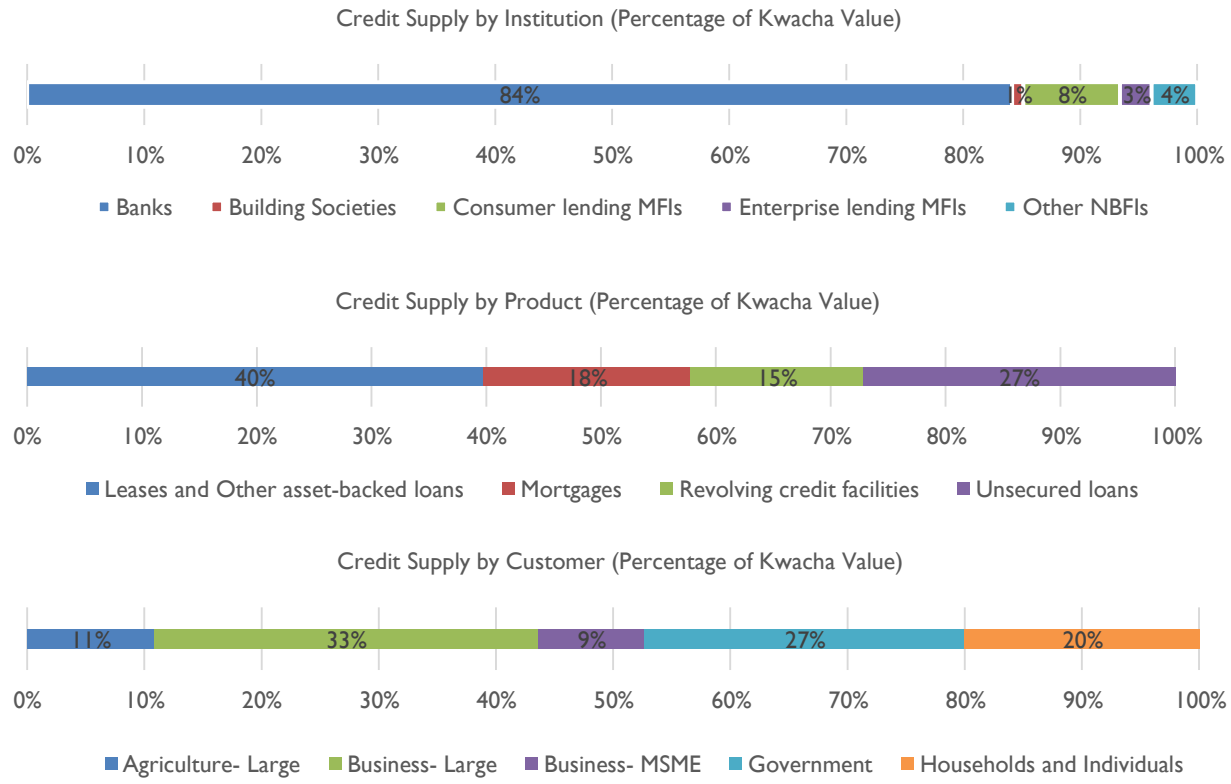


Figure 26 Credit Supply by Institution Type, Financial Product and Customer

Loans made to MSMEs were spread evenly across business sizes, but businesses with 11-20 employees received the largest share. However, only 16% of MSME loans were unsecured, which is significantly lower than the overall industry figure. In addition, the value of loans to small businesses decreased in 2019, but the volume of loans issued increased in the same period. This suggests that more loans of smaller value were given, primarily driven by credit providers lower risk appetite for this category of borrower. MSME borrowers are seen as riskier as they do not have traditional forms of collateral and do not keep adequate financial records to support applications.

Disbursements to MSMEs (Kwacha - 2020)		
Group loan	561,115,150	21%
Single person	318,157,597	12%
1-4 People	298,681,823	11%
5-10 People	316,102,602	12%
11-20 People	596,183,105	22%
21-50 People	318,251,376	12%
51-100 People	279,014,983	10%
Total Disbursed	2,687,506,637	100%

Disbursement by Large Business (Kwacha - 2020)		
101-300 employees	4,033,797,200	42%
300 to 500 employees	1,153,195,800	12%
500+ employees	4,524,134,700	47%
Total Disbursed	9,711,127,700	100%

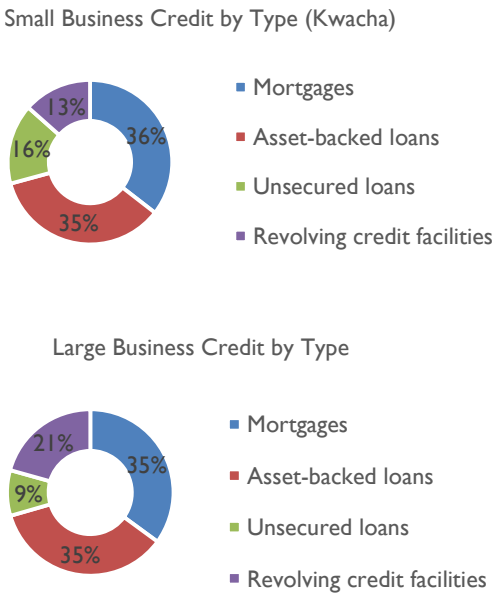


Figure 27 Credit Supply to MSMEs and Large Businesses

Loans to large businesses were spread reasonably evenly across different business sizes, but businesses with between 300-500 employees received the lowest level of lending. Again, only 9% of loans to large businesses were unsecured. In terms of financial inclusion, overall, women and youth only received 8% of total loans by value, but this increased to 24% and 20% for women and youth respectively in the small business (MSME) sector. These figures clearly indicate that women and youth experience significant challenges in accessing credit in Zambia and are not adequately represented.

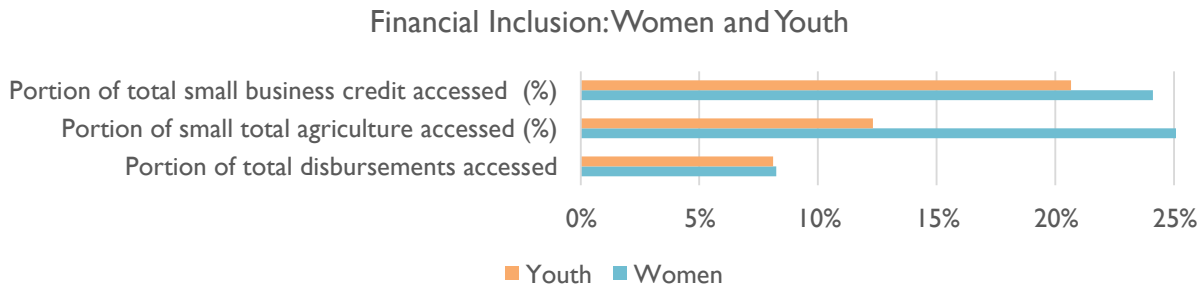


Figure 28 Financial Inclusion of Women and Youth

In Zambia, the debit interest rates for banks are determined by the monetary policy rate (MPR), which is usually set by the Bank of Zambia (BOZ) to support financial stability and growth. Currently, the MPR is 8.5% and was last reviewed and increased by the committee in February 2021 from 8%. Commercial banks in Zambia derive their kwacha denominated lending rates from the MPR by adding a margin above the 8.5%. Zambia's commercial bank lending rate was reported at 25.72% per annum in March 2021. This means that on average, most commercial banks have been adding a margin of 17.22% above MPR. Based on the information above, the average margin of 17.22% added by commercial banks above the MPR is too high and makes borrowing at both individual and commercial level unaffordable. The costs of funds from non-bank financial institutions such as micro finance institutions are even higher; on average, their interest rates are around +/-50% per annum. This makes it difficult for credit to be accessed at an affordable rate.

Given the high interest rates and risk adverse nature of commercial Zambian banks towards MSMEs, as illustrated by the low value of issued loans, the higher-than-average need for assets to secure a loan, and decreasing loan values, it is clear that many ATF companies will need to draw from other sources of investment if they are to attract the funding required to launch and scale their businesses. The exception to this is Oil Marketing Companies involved in the LPG sector. These large-scale companies already have established relationships with commercial lenders in Zambia and have the required collateral to access debt financing. That being said, many smaller LPG retailers cannot demonstrate the same financial clout as their OMC suppliers and consequently lack the financing to expand their retail outlets. These retailers often rely on their own funds, or those of family and friends to start and expand their businesses.

10.3 EXISTING FINANCING OPPORTUNITIES FOR ATFS IN ZAMBIA

CROWDFUNDING

Crowdfunding is the practice of funding a company or project by raising small amounts of money from a large number of people through online platforms. It is often overlooked as a source of financing for the clean cooking sector, and while it is still relatively small in volume, it can be an important source of future funding for the sector; particularly for companies that might struggle to raise funds elsewhere.

Crowdfunding of clean cooking is small, especially when compared to the PAYG solar sector that receives the bulk of crowdfunding energy access funding. Crowdfunding invested $159 million in energy access between 2014 and 2020, but only $8 million (5 percent) of that was directed towards clean cooking companies (Cogan, Otieno, & Weston, Clean Cooking: Scaling Up with Crowdfunding, 2021). Not all crowdfunding sites are the same; each site is geared towards a specific type of crowdfunding. Crowdfunding sites can provide peer-to-peer business lending, peer-to-peer micro-lending (asset financing for customers), equity investing, or donation/reward funding. Of the $8 million invested in clean cooking companies between 2014 and 2020, 54 percent was in the form of micro-loans for customers rather than operational funding for companies. This highlights the dearth of bankable clean cooking enterprises relative to the PAYG solar sector. Recent crowdfunding campaigns completed by clean cooking companies include Greenway Appliance's corporate debt campaign in Bettervest and multiple companies' peer-to-peer micro-lending campaigns on Kiva (Cogan, Otieno, & Weston, Clean Cooking: Scaling Up with Crowdfunding, 2021).

In all cases, there is a need to match an ATF's maturity and funding needs with the suitable platform. Non-profits and earlier-stage companies are better suited for donation/reward crowdfunding sites. Early-stage companies may be able to raise debt on venture debt platforms. Post-revenue companies looking to fund their growth are better suited for peer-to-peer business lending platforms. Crowdfunding loans have been used in Zambia as a bridge for results-based grants by Emerging Cooking Solutions Zambia and the sale of carbon credits for Greenway Appliances.

Table 29: Crowd-Funding Platforms for ATF Companies

Platform	Overview
Kiva Direct Lending	Kiva's direct lending program spun out of the 'traditional' Kiva model, which raises funds for MFIs to provide micro-loans to individuals and groups. Kiva then expanded the model to include social enterprises offering credit to their customers (including those selling cookstoves on credit), before formally starting a direct lending program for social enterprises in 2016. This program offers working capital loans of up to $100,000 or higher. Kiva's lenders do not receive interest on their loans. This distinguishes Kiva from other P2P business lending platforms, which offer interest to investors and are therefore subject to local financial regulations. Kiva's lenders are generally more philanthropically motivated than those on other P2P business lending platforms, which tend to prioritize financial return alongside impact. However, Kiva still aims to ensure capital preservation for their lenders. Kiva's due

	diligence process is less onerous than other P2P business lending platforms, but they still must get comfortable with the borrower's ability to service the loan and ensure that the loan does not create over-indebtedness. Kiva's clean cooking borrowers include Bidhaa Sasa, Biolite, Burn Manufacturing and Prime Cookstoves.
Bettervest	Bettervest is a German platform that is interested in clean cooking primarily because of its social and environmental impact. Unlike most other platforms which offer unsecured loans, Bettervest usually requires collateral to be pledged to an SPV which acts as the issuer of the debt to the crowd. In the case of clean cooking, the collateral comes from a mix of carbon credits, inventories, receivables and corporate equity. Bettervest invests in renewable energy projects across multiple sectors and countries. The Bettervest crowd is 'hardcore green' but also very traditional. They prefer well-established technologies, robust business models and solid management teams. Therefore, clean cooking is not necessarily a natural fit, even though they have managed to get comfortable using carbon credits as collateral despite the material delivery risk involved. Bettervest has completed five campaigns in clean cooking since 2019: Greenway Appliances Zambia, Bidhaa Sasa Kenya, Burn Manufacturing Kenya and Sanergy Kenya.
Energise Africa	Through its 4,000+ individual investors, Energise Africa has raised over £21 million and made £12 million in repayments, providing more than 560,000 people across 14 African countries with access to affordable and life changing energy. In the process they have also supported over 7,000 small and micro-sized enterprises. NewLight Africa raised GBP 70,000 through the Energise Africa platform to reach over 2,000 households with improved cookstoves and LPG.

DONOR-BACKED ATF VENTURE FUNDS ACTIVE IN ZAMBIA

There are several donor-funded venture funds that lend to the clean cooking sector in Zambia:

The Energy and Environment Partnership Trust Fund (EEP Africa) has funded close to €4.14 million into clean cooking technology companies in its last two funding calls. Funds were used to develop a range of technologies including new financing products, new fuels, and new distribution methods. EEP's largest clean cooking grant went to Emerging Cooking Solutions and Mimi Moto in Zambia.

The AECF has allocated $74.7 million across multiple funds that will invest in clean cooking technologies. These include AECF's REACT Innovation Fund, RBF, SSA, and SSA Somalia funds. Currently, none of the cooking funds target Zambia, but future funding windows may extend to clean cooking in the country.

The Beyond the Grid Fund for Zambia has created multiple funding windows for Zambian companies. The most recent Funding Lot closed in October 2020 and specifically incentivized new energy service providers, including clean cooking companies, to enter the Zambian market or grow further. A new Results based Finance window is scheduled to launch in 2021/2020.

The Clean Cooking Alliance Venture Catalyst Portfolio consists of 33 ATF companies operating in 13 countries, including Zambia. Zambian companies that are part of the portfolio include: Emerging Cooking Solutions, a wood pellet and stove manufacturer; Greenway, an improved biomass stove manufacturer; and Wid Energy, a solar system and stove retailer.

SPARK+ Africa is an impact investment fund initiated by Enabling Qapital and CCA to channel debt and equity financing to enterprises that manufacture, distribute, and finance clean cooking solutions across Sub-Saharan Africa. The Fund received investments totaling $16 million from the African Development Bank (AfDB) and the European Commission, with the aim of reaching 2 million households.

CARBON FINANCE

Carbon markets are an approach to reduce greenhouse gas emissions by assigning a cost to producing carbon emissions, creating an incentive to emit less, typically through offsets. A carbon offset represents one ton of carbon dioxide equivalent (tCO2e) that has not been emitted into the atmosphere and can be directly attributed to the investment/activities of the project. Offsets come from projects that reduce carbon emissions - e.g., switching fuel for cooking from unsustainably harvested charcoal to sustainably harvested biomass woodchips. Carbon finance projects must be registered and approved to generate carbon credits by any number of governing bodies that govern the carbon markets. To claim carbon credits, a project must first be registered to an international carbon standard. There are two main types of carbon markets: compliance and voluntary.

The compliance markets are the result of government regulation to reduce carbon emissions and allow regulated entities to obtain and surrender emissions permits (allowances) or offsets to meet predetermined regulatory targets. An international or government agency makes the rules about what types of offsets are permitted in the market, e.g., EU Emissions Trading Scheme (EU ETS) and Korea ETS. The United Nations Framework Convention on Climate Change (UNFCCC) created the Clean Development Mechanism (CDM) market, which began trading in 2006 to help industrialized countries meet their international commitments (e.g., Kyoto Protocol, Doha Amendment, Paris Agreement, etc.) to reduce climate emissions. The CDM has led to registration of more than 8,100 carbon offset projects

in 111 countries, from renewable energy projects to projects that spread the use of healthy, efficient cook-stoves, to large industrial gases projects. To date, more than 2 billion CER credits have been issued by the CDM, but the future of the CDM is uncertain. The CDM is currently operating via temporary measures until guidance of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (known as the CMP and which has authority over and provides guidance to the CDM) at its sixteenth meeting scheduled for November 2021.

The "voluntary carbon market" refers to all purchases of carbon offsets not driven by an existing regulatory or compliance obligation. This includes transactions of offsets created specifically for voluntary buyers, such as private companies or concerned citizens, e.g., Microsoft purchasing carbon credits to offset emissions created at the company's office buildings or individuals offsetting personal airline travel. Offsets sold on the voluntary carbon markets typically follow rules prescribed by one of a handful of voluntary standard bodies. The main voluntary standards include: The Gold Standard, Verified Carbon Standard (VCS), Climate Action Reserve (CAR), and Plan Vivo. By volume, the VCS is the largest standard in the voluntary market, followed by the Gold Standard. Cumulatively the voluntary market volume exceeded 1.3 billion tons by 2019, valued at over $5.5 billion. Household devices reduced 6.4 million tco2e in 2019, at an average price of $3.8 and a total market value of $24.8 million. More specifically, in 2019, clean cookstoves reduced approximately 5 million tons, at an average price per ton of $3.54.

In 2017, cookstove companies reported just over US$500,000 in carbon revenues, representing 1.2% of total revenues. However, this increased almost five-fold in 2018 to US$ 2.4 million, or 6% of total revenues, and more than doubled to US$ 5.2 million, or 12% of total revenues, in 2019. Almost all of the carbon revenues generated between 2017 and 2019 were by biomass stove manufacturers as part of the Clean Development Mechanism (CDM) or voluntary carbon market. Carbon revenues in the coming years are expected to increase even more, considering the emergence of the South Korean Emission Trading Scheme, where several clean cooking projects are already registered, and the upcoming dialogue on Article 6 of the Paris Agreement. In addition, updates to the carbon methodologies that allow continuous monitoring of stove or fuel usage via smart devices will encourage more project registrations by reducing the transaction costs associated with monitoring and verification.

Currently the Gold Standard is working with the MECS program to develop a methodology titled *'Methodology for Metered Cooking Devices'*. Metered cooking devices are cooking devices for heating and cooking food that either record fuel or energy use directly, or through a supplementary meter with the ability to record amount of energy or fuel used for cooking over a period of time. These may, amongst others, include induction cookstoves, electric pressure cookers, hot plates, rice cookers, solar electric cookers, and metered LPG and ethanol cookers (when metered and sold for use in a dedicated device).

Carbon offset projects come in a range of sizes, limited by the annual volume of offsets they can claim. However, commonly, project developers will create a Program of Activities (PoA) which is an umbrella framework that allows for the establishment of an unlimited number of projects that meet the criteria of the PoA. Each project under the PoA is limited in size, usually micro or small scale. PoAs are managed by a Coordinating and Managing Entity (CME) who typically encourages other cookstove companies to participate in their PoA by opening their own dedicated project. Therefore, ATF companies looking to benefit from carbon finance can engage with CMEs of existing PoAs to negotiate inclusion into their program; the table below sets out some existing Gold Standard PoA frameworks in Zambia.

Table 30: Gold Standard Carbon Finance PoAs in Zambia

PoA Name *(and link)*	Technology	Implementer	Website
TASC Clean Cooking PoA	Improved Cookstoves (wood)	The African Stove Company (TASC)	https://tasc.je/
Commonland African Improved Cookstove Program	Improved Cookstoves (wood)	Commonland BV	https://www.commonland.com/
UpEnergy Social and Climate Impact Program	Improved Cookstoves (charcoal and wood), Electric, LPG and Ethanol stoves	UpEnergy	https://www.upenergygroup.com/
African Improved Cookstoves and Clean Water Program	Improved Cookstoves (wood and charcoal), gasifier stoves and pellet fuel	Likano Project Development GmbH	http://www.likano.eu/en/

ANNEX 1: LPG AND CHARCOAL COMPARATIVE GHG ANALYSIS

See separate attachment

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