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Cover photo: A roadside charcoal stand in Lusaka, Zambia. All photographs and graphics © Aaron Atteridge and Marcus Heneen.

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Transforming Household Energy Practices among Charcoal Users in Lusaka, Zambia: A User-Centred Approach

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ABSTRACT

The practice of burning charcoal to service household cooking and heating needs, common in urban and peri-urban Lusaka as in other parts of sub-Saharan Africa, creates an array of health, livelihood and environmental problems. This study takes a user-centred approach to study household energy practices, with the goal of identifying policy and technical solutions that could induce large-scale change. It examines the drivers of current energy use practices, the capacity of households to change current practices, and the needs and wants of users that might motivate or hinder such a change. Fifteen low- and middle-income households in Lusaka were interviewed and observed. Virtually all showed some attachment to the traditional mbaula stove, which uses charcoal as fuel, but when asked about observed shortcomings, they recognized these – especially in terms of cost and health. They also expressed a willingness to explore alternatives, but cannot afford one appealing option, cooking with electricity, because it is deemed too expensive for many low- and middle-income households. The livelihood constraints of local tinsmiths who produce mbaulas, meanwhile, prevents them from investing time in exploring improvements to their stoves. The study suggests three actions might help to significantly reduce charcoal use in Lusaka: introducing more efficient cookstoves which closely resemble the mbaula and are locally made; promoting simple and inexpensive solar water heating devices to reduce charcoal demand for water heating; and electricity price re-structuring to lower tariffs for the poor. Specific design elements for an improved charcoal stove are also suggested.

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FOREWORD AND ACKNOWLEDGEMENTS

This study forms part of an SEI research programme titled Strengthening Energy, Environment and Development Processes (SEED) funded by the Swedish International Development Agency (Sida).

SEED consisted of a number of studies between 2007 and 2010 focusing on sub-Saharan Africa, examining the intersection of some of the major issues related to household cooking, energy access, modern bioenergy and livelihoods. The programme's aim was to generate new knowledge and synthesis as a basis for supporting the formulation and implementation of public and private action to increase access to sustainable energy.

This paper presents the findings of a 2010 SEED study on household biomass energy use in Zambia conducted as a collaboration between SEI, the Swedish industrial design consultancy Veryday (formerly Ergonomidesign, www.veryday.com) and local partner Apamwamba.

In addition to our project partners and funders, we wish to humbly thank those people whom we met in Lusaka, households who generously received us into their homes and shared their stories with us. Without their time and openness, such a study would not have been possible.

EXECUTIVE SUMMARY

The practice of burning charcoal to service household cooking and heating needs, common in urban and peri-urban Lusaka and in other parts of sub-Saharan Africa, creates an array of health, livelihood and environmental problems. Finding ways to reduce charcoal use is thus a priority, particularly for low-income communities. However, transforming energy markets for the poor is never easy, as the rather limited success of decades of "improved cookstove" interventions can attest to.

This paper argues that by placing energy users at the centre of the process, as agents and not just passive recipients, it is possible to identify feasible policy and technical solutions that could change behaviour at scale. We need to understand what households want and need and how they make decisions about energy and cooking.

Our analysis is based on a study launched by the Stockholm Environment Institute in late 2010, in partnership with Veryday (formerly Ergonomidesign) and Apamwamba, to explore opportunities for households in Lusaka, Zambia, to change their patterns of charcoal use. We examined the drivers of current energy use practices, households' capacity to change those practices, and, importantly, what particular needs and wants of users might motivate or work against such a change. Drawing on generative research methods that are common in applied industrial design – an ethnographic approach of interviews and observations – we sought to understand the dynamics of household-level decisions about energy and cooking practices by illuminating the array of cognitive, physical, emotional and financial factors which influence both fuel and stove choices, and households' views on alternative practices and technologies.

The study focused on 15 low- and middle-income households in urban Lusaka who rely on charcoal for daily cooking; all were interviewed and observed in and around their homes. While this is only a small number, clear patterns emerged about decision-making influences, suggesting the findings are indicative of wider patterns in these communities. While virtually all the households displayed signs of attachment to the traditional *mbaula* stove, there were also strong tacit indicators of its deficiencies in meeting critical household needs – particularly in financial and health terms – as well as the presence of a widespread willingness for alternatives.

Key findings

• Charcoal is the dominant cooking fuel in urban areas. While electricity is available in many of the urban areas surveyed and is seen as a desirable option, using electric stoves is too expensive for low- and middle-income households.

• The lower a household's income, the higher the prices it will pay for charcoal. This is because cash-flow limitations often lead poor households to buy small 1- or 2-kg bags of charcoal once or twice per day, which cost considerably more (per kilogram) than larger bags.

• Many households show a positive cognitive and emotional attachment to the mbaula. When asked, almost no interviewees cited any real problems or major complaints about the stove.

• Despite this, direct observation revealed that many of the mbaula's traits are in fact undesirable for users. These include high (inefficient) fuel use that is worse when exposed to wind; difficulty in regulating temperature, which requires close monitoring; and smoke and other fumes that cause headaches, especially when cooking indoors. Users also often burn their fingers, and the stoves can damage the floor and introduce ash into the home. In response to follow-up questions, users explicitly described the problems.

• All households expressed an eagerness to change some aspect of current energy practices. Those with a grid connection would clearly prefer to use electricity for most cooking tasks if

the cost were the same as for charcoal. Most people expressed a wish for a mbaula with lower fuel costs and improved utility.

• Cost is the No. 1 determinant of low- to middle-income households' energy practices. Hence, very few characteristics – essentially only fuel savings – would appear to motivate the purchase of an alternative, more expensive stove. Most other shortcomings experienced with the mbaula (health effects, low utility, safety concerns, messiness) are willingly accepted as trade-offs for lower fuel costs. As income rises or during short periods of higher disposable income, some choose to pay more for fuel (i.e. use electricity) to benefit from greater ease or utility.

• The livelihoods of local tinsmiths who fabricate mbaulas depend on a daily production-and-sale cycle, which means they cannot afford to invest time in improving stove design and performance. Similarly, poorer households have low capacity to take risks on new stove models or explore stove suppliers beyond their local neighbourhood. These factors may help explain the extremely low levels of innovation across the stove market – with a single mbaula model dominating an entire city market despite its many flaws.

• Still, stated willingness to pay more for a more fuel-efficient charcoal stove is high, with many households saying fuel savings would quickly cover the cost difference. The cost of charcoal stoves is also relatively low compared with other household costs, and although households cite cost as a barrier to purchasing a more expensive stove, many have managed to pay for other significantly more expensive items, including electrical cooking appliances. This suggests that stove price is not by itself (or at least not at all times) the key determining factor, but rather that the stove's perceived value.

• Mbaula production provides a livelihood for many local tinsmiths, and other poor people earn a living producing, transporting and selling charcoal. Thus, potential livelihood impacts on groups other than charcoal users should also be borne in mind in the design of future household-energy interventions.

Implications for policy-makers and cookstove programmes

Our research points at three strategies that would make sense in the Zambian context and hence could significantly reduce charcoal use in Lusaka. These are: (i) the introduction of more efficient cookstoves which closely resemble the existing mbaula stoves and are locally produced; (ii) the promotion of simple and inexpensive solar water heating devices, to reduce charcoal demand for water heating, and (iii) electricity price restructuring to lower tariffs for the poor. We also discuss specific design elements for an improved charcoal stove.

An important consideration is that although households do experience problems associated with current practices and tacitly express a desire for alternatives, they do not see the mbaula as a major problem. Future efforts to introduce alternatives should bear this in mind, particularly in their framing of the benefits of any new stove relative to current practices.

Beyond the Zambian context, this study demonstrates the value of a user-centred approach to assessing and understanding household practices in other biomass-based energy economies. We urge practitioners and policy-makers to recognize that designing clean energy interventions for households needs to go beyond the neatest technical solution. In order to catalyse large-scale change, any intervention – whether in the form of a new stove or new policies regarding energy access and use – must make sense to households on social, cultural, technical, ergonomic and aesthetic levels. It is thus essential to place energy users at the centre of the analysis when designing an intervention.

1. INTRODUCTION

In urban Lusaka, as in many other parts of Africa, charcoal dominates the household energy market. It is the main cooking fuel for most low- and middle-income households, and is also used for water and space heating. While rural areas outside Lusaka rely heavily on wood fuel, urban households generally prefer charcoal because it produces less smoke and is easier to transport and store. It is burned in a traditional *mbaula* brazier, a small, round stove fabricated with metal by local tinsmiths.

A mbaula stove in a Lusaka home.

Charcoal use contributes to air pollution and, especially when burned indoors, also damages people's health.[1] In addition, the cutting and scavenging of wood for energy is a major driver of deforestation and habitat degradation (Ministry of Tourism, Environment and Natural Resources 2002; Mfune and Boon 2008). Two-thirds of Zambia's territory – 49.5 million hectares – was covered by forest in 2010, but the country is losing an average of 167,000 hectares of forest each year (FAO 2010).

Charcoal use is also a major expense for households, particularly for the poor, and inefficient stoves lead to even higher fuel costs. The energy sector can thus play a crucial role not only in ensuring the sustainability of household energy use, but also in helping to overcome poverty – or to perpetuate it.

In Zambia, various national government policies and strategies have recognized the importance of addressing biomass energy use as a focus for tackling poverty, development and environmental goals. The 1994 National Energy Policy included the goal of reducing charcoal production by 400,000 tonnes by 2010 by promoting more efficient production and use of wood fuel and by encouraging alternatives. Similar objectives are included in the 2002 and 2006 Poverty Reduction Strategy Papers (Republic of Zambia 2002; 2006a), while the *Vision 2030* (Republic of Zambia 2006b) describes an ambition to reduce the share of fuel wood to 40% by 2030 and to achieve a "productive and well conserved natural resource for sustainable development".

Concerns about climate change offer new reasons to encourage a shift in biomass use. Zambia's 2007 National Adaptation Programme of Action (Ministry of Tourism, Environment and Natural Resources 2007) indicates that extended droughts and an increasing prospect of forest fires threaten the country's forests and could degrade land and soil fertility. This would reduce the availability of biomass as a local energy source, directly affecting low-income families that depend on biomass for cooking and lighting. In particular, growth of the Miombo woodlands will be jeopardized, which are a source of fuel wood or charcoal for more than 80% of households.

[1] The drastic health effects of indoor air pollution due to biomass burning have been well documented by the World Health Organization (Rehfuess 2006; WHO 2007) and others. While charcoal burning produces fewer soot particles than wood, it emits other toxic gases that cause problems for households (see Section 3).

Second, charcoal use contributes to rising atmospheric concentrations of greenhouse gases. In fact, Kammen and Lew (2005) suggest that from a climate perspective, charcoal is the most problematic of all biomass fuels. In addition to the deforestation driven by charcoal demand, inefficient charcoal combustion in traditional household stoves produces soot ("black carbon") which exacerbates the regional effects of global warming. Further, pyrolysis of the wood during initial conversion to charcoal inside earth kilns can also produce methane, a potent greenhouse gas (see also Bond et al. 2004; Bond and Sun 2005).[2]

Third, and arguably of most important for the communities who rely on biomass fuels, charcoal production and inefficient use could make households more vulnerable to future climate risks. For instance, wood harvested for charcoal removes mature trees that provide shade, an invaluable asset amid rising temperatures. This, in turn, affects local water regimes; according to the Zambia Millennium Development Goals Progress Report 2008 (Ministry of Finance and National Planning and UNDP 2008), "the removal of forest and woodland cover in many areas in the country is leading to the shortened flow of seasonal streams and the drying up of formerly permanent rivers. … This has serious implications on livelihood and climate change security as much of Zambia is expected to suffer from more arid and drier conditions in future" (p.26). Inefficient charcoal use also exacerbates the financial burden that poor households face when trying to meet basic energy needs, and hence diminishes the financial resources that could otherwise bolster their capacity to cope with (or adapt to) climate-related impacts such as higher food and fuel prices.

Zambia's NAPA emphasizes action to reduce deforestation (including due to charcoal) and to encourage more sustainable fuel use. It prioritizes improving the efficiency of charcoal use and encourages improved stoves to combat the effects of drought, afforestation and reforestation programs, as well as improved energy access and security (specifically including, again, promotion of energy-efficient stoves).

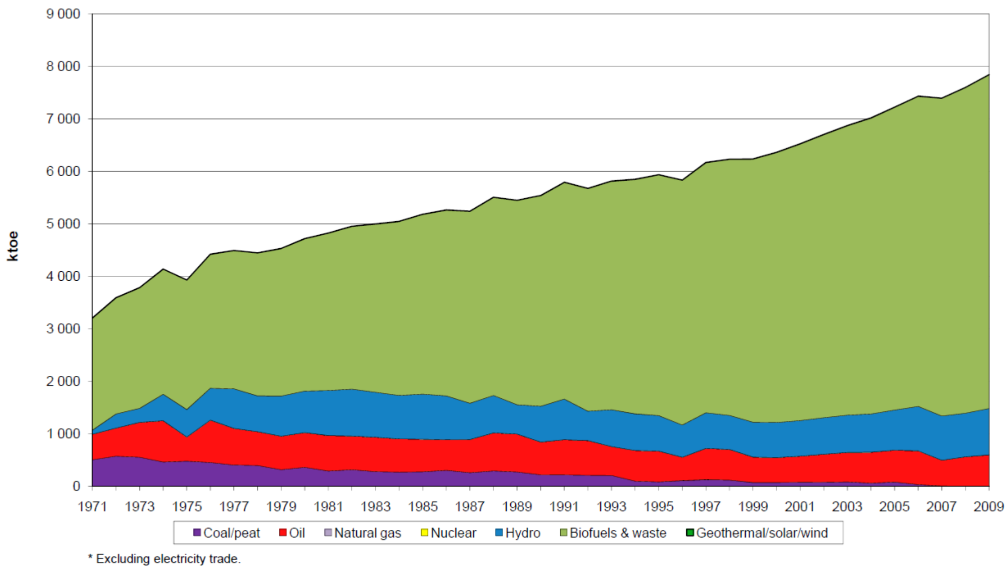
[2] For estimates in the Zambian context, see Bertschi et al. (2003).

Box 1: Using wood and charcoal to meet a growing demand for energy

As in much of the developing world, large shares of both the urban and rural population in Zambia – 57% and 97%, respectively, as of 2010 – rely on biomass as their main source of energy for cooking, and to a great extent, to meet other basic needs (Central Statistical Office 2012). The end-use of both fuels is highly inefficient in energy conversion terms: charcoal is almost always used in simple mbaula braziers, while fuel wood is burned in a traditional three-stone fire.

Zambia has domestic coal reserves and hydropower potential, but has lacked the capacity to fully exploit them (Central Statistical Office 2007); thus, as energy use has risen, forest resources have filled much of the new demand, as shown in the figure below (fuel wood and charcoal fall under the category "biofuels and waste", shown in green).

Total primary energy supply, Zambia



Source: International Energy Agency (http://www.iea.org/stats/pdf_graphs/ZMPROD.pdf; accessed 16 July 2013).

1.2 Why is catalyzing change so difficult?

There have been a number of initiatives to change energy use patterns in and around Lusaka, typically by introducing improved cookstoves. These include projects supported by the United Nations Environment Programme (UNEP) and by Japanese and German development funds, a stove manual produced by Project Gaia,[3] and a private Clean Development Mechanism (CDM) project funded by the German company RWE (see Box 3). However, as others have observed (e.g. TechnoShare Associates 2007), despite 20 years of donor- and government-funded efforts to develop improved stoves for Lusaka, none has managed to gain a permanent market share, much less transform the market as a whole.

Clean-cookstove proponents often explain this failure as resulting from one or both of two factors: lack of awareness among households of the benefits of switching fuels/stoves, and

[3] See Project Gaia (n.d.). *How to Construct a Firewood Saving Stove*. Manual produced for DAPP-Child Aid and Environment Zambia. Project Gaia. http://www.gaia-movement.org/files/stove%20manual%20TWP%20Gwembe.pdf. [Accessed 13 May, 2013].

inability to afford the higher purchase price of more-efficient stoves. For instance, a previous study noted that none of the improved stoves introduced in Lusaka had been able to recoup production costs and deliver a reasonable return on capital, and attributed this to users' unwillingness to pay a high enough price; price, the authors argued, is the key factor determining uptake of a new charcoal stove (TechnoShare Associates 2007). However, this assumption may miss a more fundamental point: that the stoves may meet technical criteria, but fail to meet the social and cultural needs of users. If they did, a viable, a sustainable business could arguably emerge and grow without external financial support.

In late 2010, SEI, in partnership with Veryday and Apamwamba, undertook a study to better understand the opportunities for households in Lusaka to change their existing patterns of charcoal use. We examined the drivers of current energy use practices, the capacity of households to change current practices, and – importantly – what particular needs and wants of users might motivate or work against such a change.

1.3 Objectives and outline of this paper

The main purpose of this paper is *to identify the kinds of actions (i.e. intervention strategies) that might create opportunities for households to make more use of cleaner fuels and/or more fuel-efficient stoves*. Such actions could range from discrete technological interventions to broader policy and financial initiatives that encourage a behavioural shift. Our analysis provides insights that can support policy decisions, projects and programmes specifically targeting the household energy sector in Zambia.

Our approach starts by recognizing that household energy use is driven not only by the technical characteristics of available options, but also by financial opportunities and barriers among both producers and consumers, as well as social and cultural factors. For example, existing practices may be linked to valued traditions and provide an important basis for social interaction, or food may be perceived as tasting better when cooked with traditional fuels and stoves than with cleaner alternatives. In many cases, these different kinds of characteristics are linked, which means there can be several related barriers to overcome at the same time.

Thus, we focus on the following questions:

- What are the most important *drivers* of current energy use practices among households?
- What particular *household needs and wants* might motivate a change and what kinds of change does this imply as desirable?
- What *capacity* do households have to change current practices?

The remainder of this section outlines the methodology used to assess household energy and cooking practices in Lusaka. **Section 2** presents the results of fieldwork, describing the important dynamics that define charcoal use practices. Finally, **Section 3** discusses what these mean for identifying strategies that could be effective in transforming charcoal use on a large scale and presents some recommendations about possible future measures.

1.4 Methodology

Previous SEI research on household energy issues in sub-Saharan Africa used a "stated preference" methodology to illuminate the interplay and trade-offs between different energy and cooking parameters in case studies in Tanzania, Mozambique and Ethiopia (Takama et al. 2011). This method prompts householders to choose between different hypothetical combinations of some pre-determined fuel and stove parameters (such as price, safety, health impacts), and thus attempts to illuminate which factors are most important to households when they make choices about energy use and cooking methods. It relies on *explicit* trade-offs, in other words what people say they would do when presented with a given choice.

This study employs a more ethnographic approach to understanding the dynamics and decision-making surrounding household energy. Ethnography is a way of studying "social interactions, behaviours, and perceptions that occur within groups" (Reeves et al. 2008). Hammersley and Atkinson (2007) describe it thus:

> In terms of data collection, ethnography usually involves the researcher participating, overtly or covertly, in people's daily lives for an extended period of time, watching what happens, listening to what is said, and/or asking questions through informal and formal interviews, collecting documents and artefacts – in fact, gathering whatever data are available to throw light on the issues that are the emerging focus of inquiry." (p.3)

We see two features of this approach as particularly valuable for studying household energy: One is that an ethnographic lens means placing people in their wider social context, which is important because of how different external factors might influence decisions taken by the household. The other is that it illuminates not only explicit but also *tacit* expressions, revealing a deeper layer of information than can be accessed through interviews alone.

Placing energy users at the centre of the analysis

In order to analyze decision-making at the individual level, we used a synthetic framework built upon insights from various disciplines, particularly behavioural psychology, ergonomics, sociology and economics. Each has something to say about how people evaluate alternatives and make choices, and thus about how daily behaviours are perpetuated or changed.

Our framework is constructed on the premise that the way people make choices and trade-offs about daily practices, in this case energy use and cooking, is influenced by:

- **Cognitive factors** – that is, *how people interpret and understand* the world around them, in particular daily practices that relate to cooking and energy use;
- **Emotional factors** – that is, the *emotional relations* that individuals have to existing technologies and practices and to available alternatives;
- **Physical factors** – that is, the *constraints and capabilities* of both the human body and the physical environment in which people live and work; and
- **Financial barriers and opportunities** – a spectrum of issues ranging from households' *willingness to pay* for different attributes or outcomes to their actual *ability to pay,* including cash flows and access to credit.[4]

To identify how each of these factors is significant in the Lusaka context, a generative research approach was adopted. Generative methods aim to produce insights that can inform action. Usually they collect qualitative data (both explicit statements and observations) to gain a deeper understanding of people's needs and desires (Hanington 2007). They may also invite people to be creative and use their imagination to think differently about an issue than they might in response to direct questions. In this study, for example, we posed hypothetical scenarios to households to encourage them to reflect on specific design aspects or character traits of both their current mbaula and potential improved alternatives. SEI has since applied a similar methodology in a study in northern India (Lambe and Atteridge 2012).

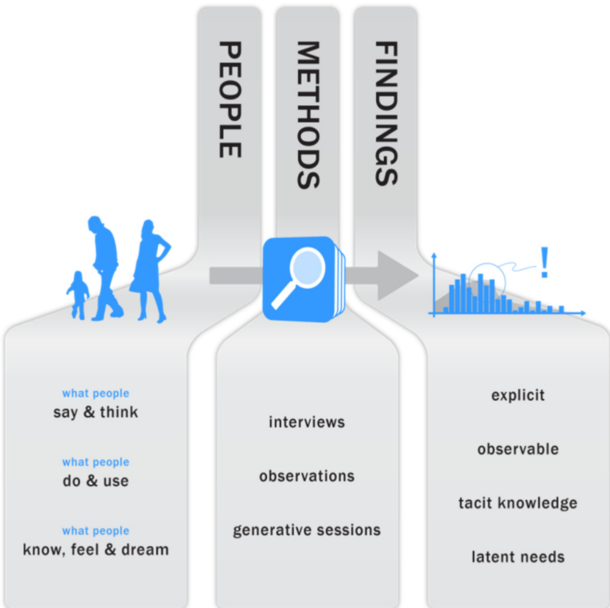
[4] Some financial questions are a subset of cognitive factors, particularly those that relate to willingness to pay for energy and for different attributes. Other financial questions are less well covered by the emotional-cognitive-physical categories described above, particularly those relating to capacity to pay, which is a function of both income and of the availability of finance in the form needed to support larger payments.

Field method: Interviews and observations

For logistical reasons, the research was limited to Lusaka and its immediate surrounds. We conducted a total of 15 semi-structured interviews in late 2010 in low- and middle-income households – groups that previous studies have indicated have highest charcoal usage rates (TechnoShare Associates 2007; Kalumiana 1997). It can be difficult to clearly distinguish between these two categories on the ground, but we relied on broad assessments by local partners Apamwamba about household income levels in different parts of the city. Semi-structured interviews with open-ended questions allowed for focused, conversational, two-way communication to generate not just "answers" but also the reasons for the answers. The research also included generative exercises, as described above.

We complemented the interviews with observations of household behaviour, particularly of cooking and living spaces and of the cooking process. This provided information about *physical* factors such as ventilation and the size and condition of housing, as well as *behavioural* information, such as about mbaula usage or household purchasing patterns (for instance, how they buy electrical appliances, which can be used to validate conclusions about willingness to pay for energy utility). Where observed behaviour matches verbal responses, this approach can be used to confirm interview results; in other cases, observation can detect nuances or even contradictions that can feed immediately back into the interviews. The interviews and observations combined thus collect both *explicit* information and knowledge (what people say and their reasoning) as well as *tacit* or latent information and knowledge (what they don't say but can be observed or inferred from their behaviour). This data generation process is illustrated in Figure 1.

Figure 1: Research methodology – data types and collection process



Source: Veryday.

Understanding broader livelihood dynamics

Beyond the immediate relationship between "users" and cooking practices (or broader household energy consumption), there are other actors and processes that are connected in the local energy complex, through charcoal production, transport and sale, as well as mbaula stove manufacture, distribution and sale. Charcoal is produced in rural areas surrounding Lusaka, sometimes hundreds of kilometres away, and transported to selling points both within and outside the city. In local neighbourhoods many charcoal sellers are small household-scale vendors selling only a few kilograms per day. The mbaula stoves themselves are made by hand by local tinsmiths in open areas of the market, using new or recycled metals.

Such local dynamics can influence how households make decisions about energy on a daily basis, so understanding them helps to identify the strengths and weaknesses of different intervention strategies aimed at transforming household energy use – especially since new fuels and stoves must inevitably compete with the existing, well-established practices.

Figure 2: Social and economic linkages that influence household energy use

The charcoal-mbaula economy is a complex social web, and a detailed mapping and analysis of this political economy is beyond the scope of this study.[5] However, we conducted a small number of interviews with tinsmiths in the areas of Mtendere market, City market, Soweto market, Kabwala market and Kalingalinga, to help us understand the wider economies of charcoal and stove production. We asked about the raw materials and tools used for mbaula production, the time required per unit, production and sales volumes, and the production process (what steps and skill levels are required). The interviews were supplemented with direct observation and visual recording of the production process. We also interviewed a charcoal producer in an area off Leopard's Hills Road, southeast of Lusaka, to discuss the production process and the economics of small-scale production. A number of charcoal sellers were also interviewed, both within the urban markets of Lusaka and at different points along the roads between rural production areas and the city.

[5] For reference, a more in-depth study of the charcoal economy in Lusaka was undertaken by the CHAPOSA project over the period 1998-2001 (Chidumayo et al. 2001)

Our interviews provide some anecdotal data on elements of charcoal production, trade and consumption, enabling us to briefly reflect any apparent differences between the situation in 2010 and that described by the more extensive CHAPOSA study a decade earlier (Chidumayo et al. 2001), and to provide a brief overview of the dynamics of stove production and sale. Most of this analysis is included in Annex 1, though it also informs the discussion throughout the main body of the paper.

2. COOKING AND HOUSEHOLD ENERGY PRACTICES IN LUSAKA

The data obtained from field interviews and observations is presented here as a combination of explicit (stated) and tacit (observed, unstated) "expressions" regarding energy use and cooking behaviour. This section describes available energy options and patterns of household use, the mbaula charcoal stove and household cooking practices, the way in which these express different household energy preferences relating to cooking (i.e. needs and desires), and some examination of willingness and capacity to pay for alternatives.

For context, our descriptions include some findings of relevant previous studies, duly referenced so as not to be confused with the data produced in this study.

2.1 Household fuel use[6]

Charcoal is the dominant fuel for cooking in urban areas, and is also often used for water heating and space heating when needed. Charcoal is generally preferred to wood because of its cleaner combustion, easy transportation and handling, and/or high heat value.[7] The Zambian government's *Living Conditions Monitoring Survey Report 2006 & 2010* (Central Statistical Office 2012) found 51.4% of urban dwellers nationwide, and 37.2% of Lusaka Province households, used charcoal for cooking.[8] Low- and middle-income groups have been identified as the likeliest to use charcoal (TechnoShare Associates 2007; Kalumiana 1997).

The rate of charcoal use depends on its quality as well as on the season. Poorer quality means more charcoal is needed, while during winter and the rainy season it is common for charcoal to be used for space heating in addition to cooking and water heating. Previous published estimates of average charcoal consumption among Lusaka residents seem to vary considerably.[9] One study estimated average monthly household usage at around 49 kg (TechnoShare Associates 2007), another at 58 kg (Chidumayo et al. 2001),[10] while the implementers of a CDM stove project in Lusaka suggested a figure equating to 114 kg per month (CDM Executive Board 2009). Our own crude estimates, based on interviews with a small number of low- and middle-income households, are closer to the low end of that range

[6] Several previous studies have examined patterns of biomass energy use and production in Zambia and around Lusaka in particular. Our own observations are based on more limited research, but may provide a useful update and new insights.

[7] Zambian charcoal and firewood are estimated to have heat content values of 32.60 and 15.50GJ/tonne respectively (Department of Energy 1992 cited in Mulombwa 1998)

[8] Charcoal use for cooking had been declining as more households switched to electric stoves. However, our field research indicates that after a major electricity rate hike in September 2010 and a crack-down on illegal connections, many households returned to using charcoal. Media coverage supports that observation:
Malakata, M. (2010). Electricity price hikes set to fuel Zambia deforestation. *AlertNet*, 24 September. http://www.trust.org/item/20100924091500-7ef2r/.

[9] The concept of presenting charcoal use as an *average*, whether in per-person or household terms, is somewhat problematic, since we observed a wide variation in reported use rates between different households (larger households did not necessarily use more charcoal overall than smaller households, for instance). The one clear pattern in our data is that larger households use less charcoal *per person* than smaller households.

[10] Per capita use in 2000 estimated at 120 kg per year, and average household size given as 5.8 people.

– around 44 kg per month, ranging from 15 to 60 kg. This translates to an even wider range in *per person* terms: from 2.5 to 30 kg per person, or an average of 9.2 kg.

Figure 3: The charcoal economy: production, transport, sale and household use

Wood is the dominant energy source for households in rural areas surrounding Lusaka, but few urban households use it their main cooking fuel. The *Living Conditions* report (Central Statistical Office 2012) shows 5.7% of urban dwellers nationwide, and 11.2% of Lusaka Province residents, used fire wood for cooking; among them, 89% collected the wood themselves. Only two interviewees in the households visited in this study used any firewood for cooking. One was a woman who said she could not afford charcoal, so she cut down fruit trees around her own house (the family used to eat the fruit). Another woman said she used firewood regularly because it was cheaper than charcoal and lasted longer; she bought it from street hawkers in her neighbourhood.

Electricity was technically available in all but one of the households interviewed, although several reported regular supply disruptions. In the household without a grid connection, our interviewee explained that although she had the capacity and willingness to pay tariffs if she was to use electricity just for lighting, she could not afford the connection fee.[11] Most interviewees use electricity for lighting, refrigeration and/or television, depending on which of these they have. For cooking, however, electricity is used only sparingly – and then only for quick tasks such as boiling an egg – because the tariffs are considered unaffordable. Almost all interviewees responded that their electricity use dropped markedly when tariffs were raised in 2010.[12] Thus, among low- and middle-income households, electricity remains a

[11] According to Haanyika (2008), the fee per connection was 769,000 kwacha in 2005 (about $140 USD by the current exchange rate).

[12] In 2010 the Energy Regulation Board authorized the Zambia Electricity Supply Corporation (ZESCO) to raise residential tariffs by 41%. ZESCO has continued to seek additional rate increases since then, but faced growing community opposition.

niche energy source, even though it is widely accessible, and households are generally willing to use it much more if it were less costly.[13]

There appear to be very few other fuels or technologies in the current market that could meet household energy needs, especially for cooking. There were no observed **kerosene** cooking devices in any of the areas visited during the field research, although previous studies indicate it is available. There appears to be no readily accessible supply of **natural gas** for household consumption; one household had imported a large LPG bottle from Botswana, though most family members still prefer to use charcoal for cooking.

Small-scale **solar energy** equipment is sold in market areas of Lusaka, and several small units were observed in use in rural areas outside the city, although not for cooking. As an indication of costs, vendors in central Lusaka (near City Market and the Cairo Road area) sell small 10-Watt off-grid systems for around 1.3 million kwacha (about $240 USD) "before discount".

2.2 The mbaula stove and household cooking practices

The mbaula is ubiquitous in Lusaka and is a central part of cooking practices. TechnoShare Associates (2007) estimated that there were 420,000 mbaulas in household use in the Lusaka urban area, an average of 1.5 per household. This section focuses on how the mbaula is produced, used and perceived. Despite its shortcomings in terms of efficiency and utility, the mbaula is a cultural institution that will not be easily sidelined in the local energy market.

Production and sale

The basic design, which is replicated everywhere, consists of three sheets of tin metal fashioned together by hand, usually in a circular shape (see Figure 4). Holes are punched out around the side walls to allow air to flow into the charcoal, and a thin wire handle enables the stove to be carried relatively easily.

[13] Our field research suggests that some caution is needed in interpreting energy use statistics. Even households that report using electricity for cooking may not do so exclusively (as noted, those we encountered use it sparingly), and would cook with charcoal the rest of the time.

Figure 4: The mbaula charcoal stove

Mbaula stoves are hand-produced by local tinsmiths using simple hand tools, as shown in Figure 5. It is common for recycled metal to be used, for instance wrecked car parts delivered to the tinsmiths by local metal collectors, though sometimes they buy new sheet metal. A tinsmith can produce a regular household-sized mbaula in around 30 to 60 minutes; the tinsmiths interviewed reported selling two to five per day. These craftsmen may also make other small metal items, such as pots. During our visit in 2010, a small household mbaula cost around 10,000 kwacha (less than $2 USD), while a larger household model might cost 20,000 kwacha ZMK (2010 figures).

Usually the tinsmiths informally occupy an open space in or near the markets around the city, rather than any formal dwelling. Stoves are sold directly to households at the point of manufacture. TechnoShare Associates (2007) estimated there to be around 600 tinsmiths operating at 50-plus market areas in Lusaka, each producing about 50 units per month to supply the market for replacement stoves.

There appears to be almost no innovation in mbaula design, with the same basic model and production process observed across all surveyed areas of the city. A small number of square models were observed in markets, though none were seen in use. Tinsmiths indicated that the common round shape of the stoves prevails because this is the easiest and quickest to make.

Figure 5: Tinsmiths produce the mbaula in local markets

Using the mbaula

The charcoal stoves are used to prepare all meals where cooking is involved. Breakfast might consist of porridge and tea. However, some women said they didn't have time to cook breakfast before they leave for their daily activities. Lunch and dinner typically consist of some relish of vegetables and/or meat as well as n'shima, a Zambian staple food made by cooking cornmeal (*mealie-meal*) porridge into a thick paste. Other common dishes include beans and capenta (small fish). Some meals include rice.

Figure 6 shows the common use sequence for people cooking with the mbaula. Observing all the individual steps that cooks must go through reveals potential opportunities for innovation to make the process easier. These are not always obvious from a quick view of someone cooking or interviews.

Figure 6: Cooking with a mbaula, step by step

The cooking sequence begins with the relish, requiring one or two separate pots. Once it is ready, the n'shima is prepared; it is always cooked last so it can be eaten hot, while the relish is usually reheated shortly before the meal. A typical relish and n'shima meal takes one to two hours to prepare. Some other traditional dishes using beans and fish take longer – two to three hours, according to most, though some suggested beans can take four hours. A typical cooking experience might be as follows:

- The stove is placed outside and filled with charcoal and kindling. It is not always easy to find kindling; the women use anything from small twigs, to leaves, paper or, in some cases, plastic bags ("if we have nothing else"). A few interviewees used paraffin to help ignite the coals.
- After 10 to 15 minutes, the charcoal reaches a "mature glow", and the stove is ready for use. The stove is always placed outside while heating, because it gives off strong fumes which cause headaches and sickness if indoors, and also because wind can help the coals to ignite.
- In most cases cooking also takes place outdoors, though most women would prefer to cook indoors. Interviewees said they stay outdoors because (i) it gets too hot indoors (it is common for low-income households to live in one very small room with poor ventilation), and (ii) the fumes cause health problems. During the rainy season and in some cases during winter, when heat from the stove is desirable, the mbaula is sometimes be used indoors.
- Many users place the stove inside a steel bucket to protect it from wind and make the charcoal last longer. One interviewee explained, "Without the bucket, lunch would consume around 3,000 kwacha of charcoal, with the bucket it consumes around 2,000 kwacha worth".
- The lower the quality of the charcoal, the larger the amount needed, and the longer the cooking time. Sometimes relish and n'shima can be prepared with one load of charcoal; other times it takes more because the charcoal burns too fast.
- One way of regulating temperature during cooking is removing some coals so the fire burns more slowly; some women also add water to the food while it is cooking. However, the women generally choose to attend the stove constantly to avoid burning the food.
- Cooking n'shima requires some force in stirring the mixture, and one interviewee suggested that it is good to have handles on the pots for this reason. This also indicates the need for a strong, stable stove design.
- Once cooking is finished, most households empty unused charcoal onto the ground and pour water on it, so it can be reused. One woman indicated that once the mbaula is lit in the morning she leaves it burning through until lunch time (by adding small amounts of charcoal when needed) because of the hassle of lighting the stove when it is needed.

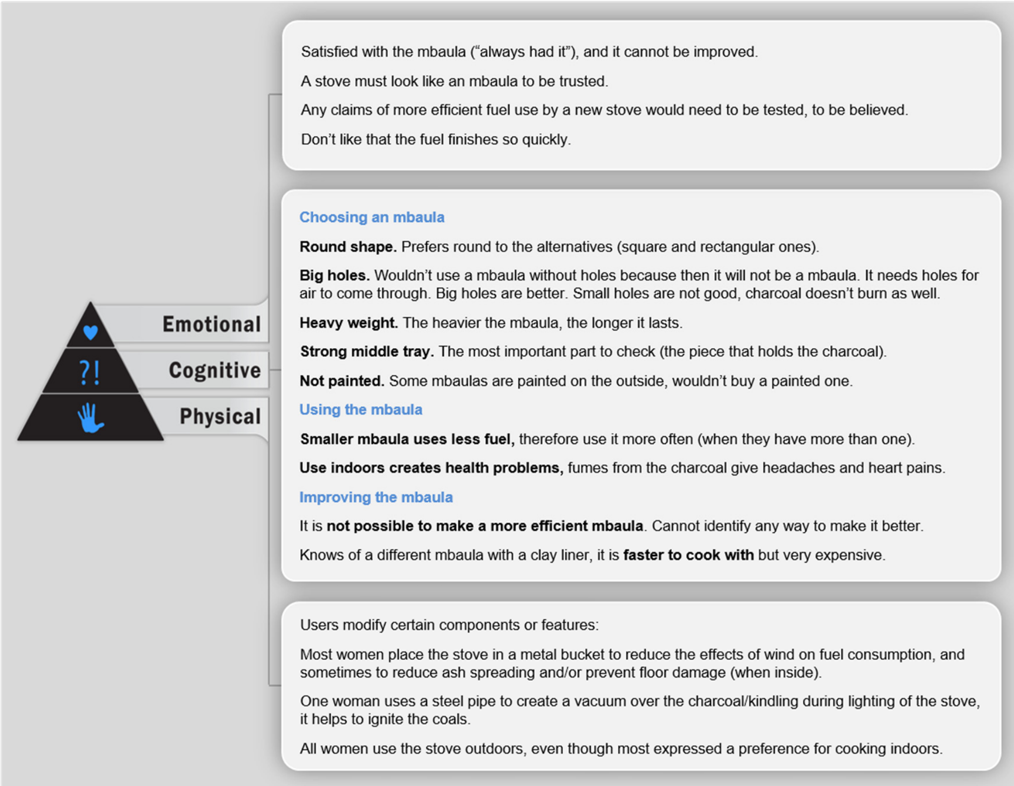
The typical lifespan of a mbaula is one to two years, and TechnoShare Associates (2007) estimated around 30,000 mbaulas are replaced every month in Lusaka. Interviewees indicated that the most common reason why they replace a stove is deterioration of the middle tray, and in some cases the base of the stove, due to heat damage.

2.3 Household energy preferences

User reflections on the mbaula

Figure 7 summarizes our reflections on the emotional, cognitive and physical responses women have to their mbaula stoves.

Figure 7: Interviewees' perception of and relationship to the mbaula stove



In general, women's attitudes towards the mbaula were overwhelmingly positive. Asked to identify particular problems or features they would like to change, almost all replied explicitly that there is nothing wrong with the stove, that they are accustomed to using it and like it. The only exception to this was a common wish for the stove to use less fuel, so it would cost less.

However, direct observation and follow-up questions revealed a range of problems that users experience with the stoves. In order of apparent significance, these are:

- The amount of charcoal consumed imposes a significant financial burden on all households interviewed. Some of the poorer households had so little cash flow that they bought charcoal twice daily rather than in larger quantities. This in turn has financial implications, since smaller bags cost more per unit weight than larger bags, meaning *the poorest people pay the most for fuel*. Note that monthly expenditures on charcoal far outweigh the purchase cost for a new mbaula.
- The fumes given off by the charcoal, in particular immediately after lighting the stove, cause significant discomfort and force most cooking to take place outside. (When plastic bags are used as kindling, they give off their own pungent, chemical odour.) The fumes are compounded by the amount of heat given off by the stove. Both factors work

against the expressed desire of almost all interviewees to be able to cook indoors for security, privacy and cleanliness reasons.

- The ash is poorly contained and is easily spread by the wind.
- It is relatively common for women to suffer minor burns when using the stove. This is partly due to the fact that they often handle the burning charcoal with their fingers.
- The process is time-consuming. As noted above, lighting the stove takes 10 to 15 minutes, and the difficulty in regulating temperature makes it necessary for women to attend the stove almost constantly while they cook. This constrains their ability to simultaneously perform other tasks.

Understanding mbaula users' needs and desires

Table 1 synthesizes households' direct statements and tacit expressions into a series of *expressed needs and desires* with respect to energy use practices for cooking.

Table 1: Evidence of household needs and desires regarding cooking practices

Need / desire	Evidence
Use less fuel (to save money)	Explicit: Many said they most often use the smaller of their mbaulas (if they had several) because it uses less fuel than a larger one. Almost all households indicated they would pay more for a stove that uses less fuel. Tacit: Observed placement of stoves inside metal buckets to protect them from the effects of wind on fuel consumption.
Faster cooking	Explicit: Prefer electricity because it cooks faster than mbaula. Tacit: Many have purchased electrical appliances (and used these more when tariffs were lower). Some use electricity for certain foods (e.g. boiling an egg) because it is much quicker.
Greater ease of cooking – quicker start up time, temperature control	Explicit: Prefer electricity because starts up faster and gets hot quicker than mbaula, and because you can modify the heat, so can turn it down and go away and do something else. Tacit: Purchased expensive electric stoves or grills or microwave ovens (which are now rarely used for cost reasons).
Less smoke (among wood users)	Explicit: Will cook outdoors when there is no wind, because there is less of a problem with smoke.
Fewer fumes (among charcoal users)	Explicit: Many expressed problems with headaches and sickness because of fumes from the charcoal. Usually cook outside even though would prefer to cook inside. "Takes pills and drinks lots of water" to deal with headaches. Tacit: Mbaula always lit outside, and cooking outside where possible.
Ability to cook indoors	Explicit: Most expressed a preference for being able to cook indoors, for a combination of security, cleanliness and privacy reasons. Even in very small rooms, women would like to be able to cook indoors but often it is too hot and fumes are always a problem.
Reduced susceptibility to wind (especially as it relates to fuel consumption)	Explicit: Interviewees explained that the stove was placed inside a metal bucket to protect coals from the wind. Tacit: Observed that many women have placed mbaula inside a metal bucket and/or sheltered corner outside the house.
Mobile stoves	Tacit: There is a need to be able to move the stove, to protect it from wind and/or to cook inside sometimes.
Ability to cook without suffering burns	Explicit: Many interviewees indicated that it is easy to burn oneself using the mbaula, mainly it seems due to the practice of moving hot coals around by hand (which women do for the sake of convenience).
Prevent ash from spreading	Explicit: Interviewees explained that placing the stove inside a metal bucket helped reduce the spreading of ash. Tacit: Observed that many women have placed mbaula inside a metal bucket.

Provide heating during winter and rainy season	Explicit: Many interviewees stated that they take the mbaula indoors during the rainy season and/or winter period, for heating. This contrasts with another expressed idea that excessive heat from the stoves is one reason women choose not to cook indoors even though they would prefer to.
Get stove off the floor (to prevent floor damage)	Explicit: Several interviewees explained that they put the stove on something else when it is inside the house, to protect the floor. Tacit: Observed placement of stove on metal trays or brick slab.
Enhance food taste	Explicit: Some indicated that food tastes better when cooked on charcoal, compared to when cooked with electricity. There was no consistent pattern among interviewees in which kinds of food taste better on charcoal – some said beans, one said n'shima.
Ease of fuel procurement	Explicit: Some stated they would prefer to use electricity if it was affordable because it saves the effort of having to go out to buy fuel on a daily basis. Tacit: Many have purchased electrical appliances (and used these more when tariffs were lower).

Desire to change current practices

A consistent pattern across all households interviewed was an eagerness to change some aspect of current energy practices. Those with a grid connection expressed a strong preference to make much greater use of electricity for cooking. Virtually all mbaula users expressed a tacit and sometimes explicit desire for a stove with improved utility and lower fuel costs. Table 2 summarizes the cognitive rationale for these preferences, as well as the reasons given for not making a change.

Table 2: Fuel and stove switching: cognitive rationale and barriers for households

Preference	Reasons given for enacting preference (or for wanting to)	Reasons given for not acting (i.e. barriers to pursuing preference)
Switching from charcoal to electricity	Ease of use – Cooks faster; temperature can be regulated more easily – Don't need to go out to buy fuel – Enables parallel cooking of dishes – Pots don't need scrubbing after use	Usage cost (tariffs); many household have electrical appliances already and want to use them, but cannot afford to High cost of connecting to the grid Lack of access (in rural areas). High cost of off-grid solar units (rural).
Improved mbaula for cooking with charcoal	Reduced fuel needs (i.e. more efficient) Ability to protect mbaula from wind, in order to lower fuel use Ability to control temperature	No alternatives available in local market Hesitance to buy something that does not look like a mbaula; not sure whether it will work or save fuel

As noted above, some households modify their mbaula in response to perceived problems or deficiencies with the existing technology. Figure 8 shows some examples.

Figure 8: How households innovate to overcome problems with the mbaula

2.4 Economic and financial barriers to changing energy use

It is important to understand the extent to which households can afford to change practices and how willing they are to pay for different attributes of an alternative fuel or stove (e.g. higher efficiency, improved safety, reduced health problems or greater cooking utility).

Willingness to pay

A robust willingness-to-pay evaluation was not conducted as part of this study. However, we asked households whether, if an improved but more expensive stove were available, they would be willing to pay more for it (than for a standard mbaula), how they might pay for it, and why. We also observed tacit indications of a willingness to pay for alternative energy services – for instance, in household purchasing behaviour.

Households consistently said charcoal costs are a major portion of household expenditures, and all but one interviewee articulated a clear willingness to pay a higher up-front price for a new *more fuel-efficient* stove. Most had no hesitation in saying they would pay double or even triple the price of a new mbaula if it demonstrably reduced charcoal needs.

They also often expressed, tacitly and explicitly, a willingness to pay for *improved energy utility*. For example, many have purchased expensive electric stoves, citing benefits such as faster cooking and enhanced temperature control. Several households had an electric oven with stove top, which they said cost 1.2 million to 1.8 million kwacha (this is consistent with prices quoted for equivalent models sold new in markets close to the centre of Lusaka, which were upwards of 1.5 million kwacha). Small electric coil stoves were observed in several households; prices were quoted as 65,000 kwacha for a single-coil stove and between 120,000 to 170,000 kwacha for a double-coil model – substantially more than the 10,000 to 20,000 kwacha price of a new mbaula. It is possible that some of these purchases were made at a time when electricity access was "free" (i.e. illegal connections) or tariffs were considerably lower, in which case the economic calculus would have been different than today.

Capacity to pay and access to finance

The price of a mbaula in local markets appears on the surface to be a relatively small expense when compared with other household costs, as shown in Box 2. It is a fraction of monthly charcoal costs, for instance, which for households interviewed ranged from 30,000 to 150,000 kwacha (dry-season rates). If the total stove cost is spread over its one- to two-year lifespan then in monthly terms the purchase cost is very small.

Box 2. Indicative household costs

To put fuel and stove costs in context, the following summarizes a range of other regular household costs quoted by interviewees. This list is intended to be indicative of the scale of household expenditures, rather than present precise figures.[14]

Number of occupants	Other costs, in kwacha (monthly unless indicated)
4	Rent 300,000; food 450,000 – 500,000; school fees 650,000 per term (twice per year); rubbish collection 15,000; electricity 250,000 (split with neighbours).
6	Electricity 200,000; cornmeal for n'shima is the other major cost; mother's mobile phone 80,000 (credit bought in packets of 5,000 or 10,000) and daughter spends 10,000 or 15,000 *per day* on mobile credit; water 10,000.
7	Electricity 200,000; food and water are the other major costs.
2	Food 450,000.
3	Food 800,000.
7	Electricity 300,000 (without using stove).
4	Electricity 80,000 to 100,000; school fees 750,000/term (twice per year); food 150,000.
8	Electricity 250,000; food 500,000; school fees 650,000/year; water 80,000 to 120,000; mobile phone 300,000 (for mother alone).

The monthly charcoal costs cited by households were: 50,000-100,000; 30,000; 90,000+; 120,000; 95,000-120,000; 60,000; 20,000; 150,000; 20,000 (for wood rather than charcoal); 60,000+ (more when cooking beans); 55,000-60,000. Expenditure on charcoal varies depending on both the quantity in which the charcoal is purchased (larger bags are cheaper per kilogram) – which is related to a household's financial position – as well as the season (rainy-season prices can be substantially higher than during the dry season).

However, with little innovation in the stove market in terms of higher-efficiency models, households appear reluctant to buy anything but the cheapest available stove. Implicit in this is a willingness to trade off lower utility or greater health impacts for a lower stove purchase price. This attitude appears to be linked specifically with the mbaula, since it is inconsistent with the other household spending practices described above.

[14] According to the *Living Conditions Monitoring Survey Report 2006 & 2010* (Central Statistical Office 2012), the average monthly household income in Lusaka Province in 2010 was 1,779,000 kwacha, but 24% of households had incomes under 450,000 kwacha, and 21% earned 450,000-800,000 kwacha. The average monthly household expenditure for in Lusaka Province was 1,930,000, including 675,000 for food; notably, housing costs are particularly high in Lusaka, taking up 33% of household expenditures (vs. 35% for food). Lusaka has the lowest poverty rates in the country, but 11.5% of the population lives in "extreme" poverty, defined as being unable to afford a basic food basket, valued at 96,366 per adult month. Another 12.9% are "moderately poor", meaning can afford the food basket but have incomes of less than 146,009 kwacha per adult per month.

Most households recognized that a higher-efficiency charcoal stove would very quickly pay back its higher purchase costs through fuel savings, but several cited the lack of finance for making higher capital outlays (at purchase) as a barrier. Some interviewees said they do have the ability to borrow small amounts of money locally, while others said had no access to credit, even though they might know people in the community who sometimes offer loans. Poor households that struggle on a daily basis to buy food and enough charcoal for cooking likely find it difficult to take even small loans under normal circumstances. Still, observed purchasing behaviour suggests that many households do have the capacity – at least at some times – to pay more for an improved charcoal stove.[15]

3. PATHWAYS FOR TRANSFORMING CHARCOAL USE IN LUSAKA

If interventions to reduce charcoal use are to be effective, they need to be socially and financially sustainable in the longer term. To accomplish this, they must respond to the problems as experienced by local people as well as to the array of social, cultural and financial factors that influence daily household decisions about cooking and energy use.

Drawing on the findings presented above, this section illuminates benefits on which efforts to encourage a shift in household energy use patterns should focus in order to be most effective. It then proposes three specific actions that, if well designed and implemented, could create opportunities for households to change practices and, in doing so, would meaningfully reduce charcoal use in and around Lusaka.

3.1 Understanding household energy use

The *preferences and desires* expressed by households represent the space, or opportunity, for catalyzing a change in current practices. Here, reduced fuel consumption, reduced health impacts, greater utility, a preference for cooking indoors, and willingness to pay more for a fuel-efficient stove are all significant. In Lusaka, fuel costs are a significant portion of low-income households' expenditures, and the most pressing problem which dictates cooking practices. Although the mbaula has many shortcomings (health effects, limited utility, safety risks, messiness) were willingly accepted as a trade-off for lower fuel costs.[16] There is also a strong cultural attachment to the mbaula stove.

Various *material constraints* can work against change. There are few alternatives in the energy and stove market – kerosene is not used for cooking, there is little or no natural gas, and there is no viable solar cooking option. Also, cost is a major issue: low-income households generally have little ability to take financial risks, which reduces their willingness to buy more expensive stoves whose performance is unfamiliar.

There are also *normative barriers* to overcome. The mbaula is a strong cultural device with generally positive connotations amongst users. Despite its clear and acknowledged flaws, it is not perceived as needing to be changed. Further, user perceptions of what are important stove characteristics are based on the traditional mbaula, in part because of few opportunities to try

[15] The *Living Conditions* report (Central Statistical Office 2012) shows 80% of urban households in Zambia owned a mobile phone in 2010, 60.9% a television set, 56% a radio or stereo, 42.9% an electric iron, 42.5% an electric stove, and 37.2% a DVD or VCR unit.

[16] These conclusions appear to align with the results of a survey by a previous improved stove programme. Users of improved clay stoves – introduced in Zambia (including Lusaka) and several other Southern African countries – valued fuel savings as the No. 1 attribute of an improved stove, followed by greater utility in terms of quicker and easier cooking. Less smoke was important to only 4% of survey respondents (Brinkmann and Klingshirn 2005).

alternatives (which means new stove entrepreneurs must allow space for testing and learning among intended users). Some people feel food tastes better on charcoal stoves than when cooked with electricity, even though few have much experience cooking with alternatives.

These factors, summarized in Table 3, must be understood and reflected in the design and pricing of alternatives if such alternatives are to become attractive to users. Not all barriers described above are likely to be "game breakers". For instance, despite their attachment to the mbaula, more than 90% of the medium-income and even low-income households interviewed have an electrical connection and have already purchased more expensive electrical cooking appliances, which they used preferentially when tariffs were lower.

Table 3: Barriers to and opportunities for change in energy and stove use

Factors acting as a barrier	Many households have a positive attitude towards the mbaula. Amongst elder respondents in particular there is a strong sense of loyalty to the traditional way of cooking and a cautious or disinterested response towards new technologies. We observed no questioning of the mbaula design or any *conscious* expression of discontent.
	Few efforts to vary, innovate or optimize stove design were observed amongst mbaula producers. It is worth noting that mbaula users are predominantly women, while the stoves are produced only by men.
	Access to finance to pay higher purchase costs of a more expensive stove are limited. Households have low ability to take financial risks, and a new model stove carries with it some risk since its reputation is unknown.
	The costs of electricity for cooking are deemed too high by households, meaning it is used sparingly.
	Some people feel food tastes better when cooked in traditional stoves compared to alternative fuels such as electricity.
Factors favouring a change	Fuel is a major cost item, particularly for low-income households, whose cash-flow constraints force them to pay higher prices for charcoal. Alternatives that lower fuel costs would be greatly welcomed across low- and middle-income households.
	The mbaula is susceptible to wind, which has a big effect on fuel consumption. It also affects health, since women will move the stove indoors during high winds even though this gives them headaches and makes them sick.
	There is a tacit desire for innovation, seen most notably in expressions of women using the stove – almost all actively modify the stove in some way in order to overcome some of the problems they experience with it (e.g. wind exposure, ash spreading, heat damage to floors, long time waiting for the charcoal to light and reach a mature glow).
	Cooking with the mbaula is time-consuming, and women have little freedom to leave cooking unattended in order to do other things simultaneously.
	There is a willingness to pay more for a more fuel-efficient stove. Households also show evidence of paying more for greater utility, such as for electrical stoves. This observed behaviour somewhat contradicts statements about inability to pay for higher-cost stoves.

Of the desires for change described in Table 3, not all were verbally articulated (explicit). Particularly in relation to choice of stove, the interviews were able to bring to the surface both a desire for change and the kinds of change seen as desirable *only by observing and reflecting on current cooking practices*, and thus deconstructing specific activities and observed experiences into questions about costs, health effects, utility of use, and so on. By contrast, questions posed directly about the benefits or weaknesses of the mbaula were usually met with a response like "there are no problems with the mbaula".

That there appears no active practice of questioning current cooking behaviours could be partly related to a wider observation, that there is a lack of innovation generally in the production of charcoal stoves around Lusaka. Poor tinsmiths probably cannot afford to spend time testing different models and approaches, and this is likely to at least partly stifle innovation. The fact that all producers are men, while all users are women, might also create some disconnect in the innovation process, though this is speculation. Whatever the reason, the fact households are not accustomed to reflecting on or questioning stove choice and use sets up a catch-22 scenario: producers see no signals that users want a change, while users see no alternatives by which they might imagine benefits.

3.2 Pathways for transforming energy use

When we place the people using charcoal on a daily basis at the centre of the picture – not just as recipients of a new technology but as the adjudicators of what makes sense and what doesn't – we can see at least three opportunities to help transform charcoal use in Lusaka.

First, there is a market opportunity for *a stove that closely resembles the mbaula, but makes notable efficiency improvements*. Second, part of the demand for charcoal and firewood could be reduced by households installing *cheap solar water heating devices*. A third possibility for changing household energy use is *lowering electricity prices for poorer households*. These options are discussed below.

A more efficient charcoal stove with broad user appeal

The typical lifespan of a mbaula stove is only six months to two years, so an improved stove that appealed to buyers could rapidly gain market share. However, previous efforts to introduce an improved stove have failed to take off at scale. One reason may be that these efforts under-appreciated the mbaula's institutional strength, or the depth of appreciation and goodwill people have for it. Introducing stove models that are far removed in design terms (e.g. clay stoves) can work in some settings, but also risks alienating prospective users.

The other key challenge is to make such stoves affordable. Virtually all interviewees indicated a strong willingness to pay more for a stove (than the current mbaula costs) if it saved them fuel, since fuel is a much higher monthly cost than stove purchase. When asked if they would pay five times as much for a stove as the current mbaula price, some immediately responded they would, reasoning that the payback time in terms of fuel savings would be very short. These statements are substantiated to some degree by observations about previous energy decisions and purchase patterns. For instance, many households had paid very large sums of money – in some cases a staggering two orders of magnitude greater than mbaula costs – for electrical cooking appliances that they perceived to offer greater utility. However, it is also the case that most households have limited cash flow, no access to credit and usually no mechanisms for paying in instalments to spread costs over time.

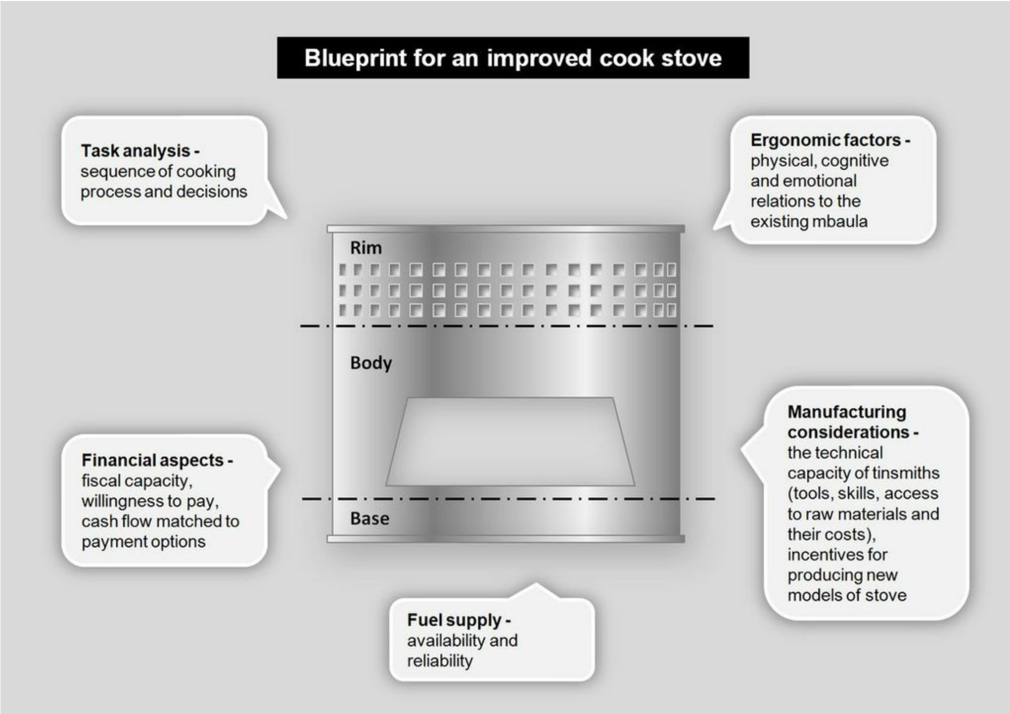
An array of data described above informs the development of a "design platform" for an improved stove that could appeal to charcoal users in Lusaka. As outlined in Figure 8, some insights come from the household interviews, namely:

- **Ergonomic factors** – physical, cognitive and emotional. From these we can identify which traits of an improved stove would meet the needs and wants of users.
- **Task analysis** – sequence of cooking process and decisions. From this we can identify in which stages or sequences people would appreciate improvements or changes.
- **Financial aspects** – fiscal capacity, willingness to pay, cash flow matched to payment options. From these we can understand the capacity and willingness of people to pay for improved energy options.

Other useful insights come from the interviews with existing stove makers (tinsmiths) and vendors, in particular:

- **Manufacturing considerations** – the technical capacity of tinsmiths (tools, skills, access to raw materials and their costs), their incentives with respect to producing new models of stove. From this we can see whether improved stove interventions might be able to harness existing tinsmith capacities (and place in the market) and, if so, how attractive different improved stove designs may be to tinsmiths given time and costs. Alternatively, it allows us to get a better sense of whether alternative manufacturing options would be needed to produce a more efficient stove.

Figure 9: Blueprint for an improved cookstove



Features that our analysis suggests would be most valued by low- and middle-income Lusaka households are summarized in Table 4. Not all of these would motivate stove purchase. For example, while there is a risk of users burning themselves with the mbaula, none of the interviewees shared stories of themselves or children suffering severe burns. While lowering this risk is a *desirable* design feature, it is therefore arguably not an *essential* one, particularly if it significantly adds to stove cost. Users are accustomed to devices with hot outer shells, and other concerns are far more significant in influencing household decisions.

Table 4: Important features of an improved stove from user perspective

Highest priority	**Fuel efficiency (including protection from wind)**
Primary features (i.e. could play some part in influencing decisions)	Enable cooking indoors (hence, minimal harmful gases)
	Greater cooking utility, including fast start-up and greater temperature control
	Mobility
	Prevent ash from spreading
	Robust (some dishes such as n'shima require forceful cooking)
	Must accommodate common pot sizes
Secondary features (i.e. would be appreciated though probably not influence purchase/use decisions)	Enable charcoal to be added without removing pot
	Reduce burning risk
	Enable visual inspection of glowing charcoal (users are accustomed to watching the charcoal as a means of monitoring their cooking)

Some of these are consistent with conclusions of a previous study (TechnoShare Associates 2007), including higher efficiency (which they posit should be achieved by higher temperature combustion), safer use indoors for cooking and space heating (achieved by utilizing "pre-heated secondary air" to burn the carbon monoxide given off by charcoal), reducing burning risks for users (achieved by ensuring a stable design to lower the chance of the stove being knocked over and by lowering the temperature of the outer shell of the stove), mobility (achieved by attaching a wire handle) and ash collection (achieved by a tray).

On the question of purchase cost for consumers, TechnoShare Associates (2007) argued that the price of an improved charcoal stove would need to be lower than 12,000 kwacha (equivalent to twice the price of an ordinary mbaula in 2007) in order to be able to compete with the mbaula for market share. Our results indicate that an improved stove could be significantly more expensive than the current mbaula, provided that fuel savings are clearly conveyed and demonstrated to buyers. This study did not attempt to accurately quantify maximum stove costs, but our indicative data, based on conversations with households about willingness and ability to pay for more fuel-efficient stoves, suggests an unreserved willingness to pay double or triple current mbaula costs for a more fuel-efficient stove.

We concur with the TechnoShare Associates (2007) finding that daily cash flow constraints (i.e. households working with 10,000 kwacha per day) may make it difficult to build the "surplus income" needed to save money for a higher-priced stove. At the same time, as noted before, the fact that households have paid much more for electric stoves and pay significantly higher amounts every month for services such as mobile phone credit, indicate some ability to raise money when the desire is great enough. Nonetheless, household financial constraints mean a business model that enables instalment payments (as has been used by the Lusaka CDM project) would be welcomed and would likely increase uptake.

The choice between a high-tech or low-tech stove

Various scenarios are conceivable for improving stove efficiency, as in Table 5, ranging from a stove based on incremental, low-tech improvements (i.e. small modification to the existing mbaula design) through to high-tech, "leapfrog" or step-change improvements in technology. Each approach has different advantages and disadvantages, and importantly, each has different consequences for user uptake.

The "perfect" technical solution may not necessarily be the most effective, in terms of market penetration and overall impact. A failing of many stove interventions worldwide has been a failure to recognize that technical parameters must sometimes be traded off in order to meet other user needs or expectations. While this can mean lower efficiency *per stove*, the overall benefits in terms of fuel and economic savings can be greater if the approach successfully stimulates greater uptake of the new alternative by households.

Table 5: Scenarios for improving stove efficiency

Scenario	Technical options	Stove producers
Low-Tech 1	Improved mbaula, made from existing materials and tools	Existing tinsmiths
Low-Tech 2	Improved mbaula, made with some new materials and methods but based on current resources	Existing tinsmiths
Medium-Tech	Existing fuels, new type of stove construction, more advanced design	New stove manufacturers
High Tech	New fuels (e.g. kerosene)	New stove manufacturers, new fuel supply lines

The option of introducing more complex, "higher-tech" stoves to the market usually implies more complex manufacturing processes, new and specialized equipment and/or raw materials, tools and production techniques. Often such stoves cannot be made by the same people making simple traditional stoves, which means new actors are introduced to the stove market who must compete with existing producers.

Higher technical complexity also results in higher cost. Often complex stoves also rely on the presence of an intermediary agent to oversee production and distribution, as well as to manage financial issues – particularly where external revenue streams such as carbon finance are used to lower retail prices for consumers. Pursuing designs that rely on external revenue streams, such as carbon finance, are not only administratively cumbersome but also raise questions about the long-term sustainability of the business model, since the stove cannot be organically replicated by other local actors – and hence market diffusion rates can be slow.

Further, tinsmiths make many of the existing mbaulas out of old metal scraps, which lowers costs and conserves resources. All of these are incentives for continuing with existing practice instead of pursuing alternatives that may require costly new raw materials.

An alternative approach is to redesign the traditional mbaula to be more fuel-efficient. Given the strong cultural attachment to the mbaula, something that looks similar and can be made by tinsmiths and sold in the same markets might be more readily taken up by households than a completely new kind of stove. Another advantage is that a low-tech design is likely to be simpler and cheaper to produce, and hence less likely to require external finance such as carbon revenue for ongoing business sustainability. It will also be more likely to be amenable to local replication.

A related issue is the impact on local livelihoods. Mbaulas are made by local tinsmiths, who sell them directly to users. Supplying scrap metal to them provides another livelihood base. By contrast, all improved cookstoves sold so far in Lusaka came from outside these local supply lines. Engaging local tinsmiths to make a redesigned mbaula would allow improved-stove initiatives to leverage their existing customer relations, and also support local livelihoods.

Similarly, creating neighbourhood-based distribution channels could also help. Among interviewees, several women conduct business from their homes through informal social networks, for example selling imported shoes. Helping such entrepreneurs to buy and resell improved stoves would create an initial market demand and provide a way for potential buyers to familiarize themselves with the stoves before making a big investment. Local entrepreneurs might also be able to set up instalment plans.

In summary, a low-tech improved stove approach appears more likely in this case to achieve the goals of large-scale transformation in household energy use, and thus to result in greater overall benefits for livelihoods and the environment. Similar conclusions are reached by TechnoShare Associates (2007), who point out the benefits of introducing a lower-priced stove model (relative to more complex stoves) and recognize that the network of exiting tinsmiths is well established in markets and "represents decades of accumulated social capital and technical capacity" (p.49). Box 3 summarizes some lessons that might be learned from previous efforts to introduce cookstoves in Zambia, or at least some questions to bear in mind when designing future interventions.

Box 3. Lessons from previous "improved stoves" in Zambia

There have been several efforts to introduce more efficient stoves to parts of Zambia, including Lusaka. Traditionally, improved stove programs have either:

- funded centralized manufacturers in the hope that they will successfully produce and market new stoves – this approach has been tried several times by the Africa Rural Energy Enterprise Development Program (AREED) and in both cases (Ramsa in 2001 and Ubwato in 2002) the businesses failed;[17]
- attempted to educate existing stove makers in the production of different types of stoves – this approach has been pursued by ProBEC, which has attempted to introduce metal "pulumusa" stoves (Simfukwe 2010), as well as by Project Gaia, which published a manual on how to construct a one-pot clay stove for use with firewood (see footnote 3);
- designed stoves that are made from new materials – this model has been pursued by a Japanese aid-funded project involving the Ceramics Research Unit at the National Institute for Scientific and Industrial Research (NISIR), with the goal of introducing JIKO and ZIKO stoves for charcoal; ceramic stoves have also been tried by ProBEC (Brinkmann and Klingshirn 2005; ProBEC 2010), and the stove design published in Project Gaia's manual also relies on new materials;
- introduced high-tech stoves imported from abroad –the 10-year (2009-2019) CDM Lusaka Sustainable Energy Project, implemented by the German company RWE Power, aims to replace the charcoal consumed by 30,000 Lusaka households with renewable biomass, through the introduction of a new stove (and heating container), the "Save80 Cooking System"; components for the stove are imported from Germany for local assembly;[18]

Our research suggests that these approaches risk alienating both stove users and producers. They often rely on new actors to manufacture, sell and/or manage the distribution processes, setting themselves up in competition with firmly embedded local networks and relationships. In the case of attempting to introduce stoves produced with new raw materials, physical material supply can be a potentially constraining factor, as has been experienced with the ProBEC ceramic stoves.[19] The business models underpinning the above approaches also often depend on a degree of external administration and ongoing external funding to subsidize producer costs.

Likely as a consequence of these factors, there has been very limited if any real success in significantly transforming local markets.

[17] See http://energyaccess.wikispaces.com/AREED+-+Case+Study#zambia.

[18] See RWE Power (2009). RWE climate protection project combats deforestation in southern Africa. 18 November. http://www.rwe.com/web/cms/en/113648/rwe/press-news/press-release/?pmid=4004208.

[19] See http://www.probec.net/displaysection.php?czacc=&zSelectedSectionID=sec1261042967.

Low-tech solar water heating

Households use at least some of their fuel to heat water for bathing, and solar heaters on the roof or in the yard could more sustainably perform this function. Many homes have tin roofs or other open space that can be utilized for different forms of solar water heating. The fact that many households rent rather than own their houses and also have concerns over theft would likely prevent them from installing expensive, permanent solar water heating units. However, a cheap, "low-tech", mobile and lightweight solar water heating device could appeal to low-income households. To our knowledge, there are no such devices in the market – only much-costlier options.

Electricity price reform

At present, electricity is used predominantly for lighting and in some cases refrigeration. However, making electricity available for *cooking* is the key to unlocking its potential to help with poverty reduction and forest degradation.

Technical access to electricity in urban Lusaka is quite widespread, even if reliability can be a problem, and almost all households said they would cook more with electricity if it did not cost so much more than charcoal. In fact, some households already bought expensive electrical cooking appliances when tariffs were lower, but reduced their usage when tariffs were raised in 2010 indicating their price sensitivity.

Electricity price reform is never a straightforward political proposal. However, if it were prioritized, possibilities exist for *revenue-neutral* tariff reform, which means lowering prices for low-income households yet raising overall tariff income (in line with the objectives of the government and the needs of the electricity utility ZESCO). Although this requires raising tariffs for other users, most of the current electricity subsidies already benefit higher-income groups rather than the poor (Kalumiana 2004).

A further challenge with this option is that, given problems with reliability of the network in Lusaka, any significant increase in electricity use for cooking would place further strain on the system, which already has frequent periods when demand exceeds the supply. In fact, the core rationale for ZESCO's efforts to raise rates is that it needs to keep upgrading capacity and distribution systems.[20] However, given the relatively small share of the country's total power that is used by households – 19%, compared with 68% for the mining sector (Central Statistical Office 2007) – it would make sense to reform rates in a way that makes it affordable for more households to cook with electricity

Improved charcoal quality

Conceptually, improving charcoal quality improves energy efficiency and hence reduces charcoal demand. However, as an option for transforming local energy use patterns, this is not likely to be a high-impact intervention in Lusaka. The Zambian government has already published material on how to improve charcoal production (Hibajene and Kalumiana 1994). Further, there is already higher-quality charcoal available, usually sold in supermarkets. However, for most low- and middle-income households this does not compete with cheaper, informally produced charcoal. In general, we observed a clear pattern of households making very short-term decisions about fuel purchases, which would help explain why higher-quality but more expensive charcoal has not taken off. This is supported by observations that

[20] See, for example, Zambia Online (2013). Consumers oppose 26% power tariff hike. 2 May. http://zambia.co.zm/news/local-news/2013/05/02/consumers-oppose-26-power-tariff-hike/.

competition between lower-quality charcoal and high-quality charcoal is imbalanced because the price difference is too great between the two alternatives (CEEEZ 2005).

3.3 Considering impacts on other livelihoods

Charcoal use is part of a broader social and economic network which provides livelihoods for charcoal producers, transporters and various levels of market sellers. It is therefore also important to understand the supply side of the fuel and stove market, since household choices and behaviour form part of, and are shaped by, a wider context. Various features of the incumbent charcoal-mbaula complex should also inform choices of future interventions in the household energy market.

On one hand, these established networks can constrain the competitiveness of new entrants into the market. The sustainability of the fuel and stove market is related to what resources are used (fuels, raw materials), what support services are available (production infrastructure, distribution channels), as well as economic and financial issues that influence viability from a domestic business perspective. Existing mbaula production is small-scale and local, and stoves are sold directly at markets (i.e. the point of production). This distributed model poses a competitive challenge to efforts to transform stove choice across the Lusaka area. Mbaula production commonly also reuses old metal supplied by local metal collectors, and the stoves utilize a fuel, charcoal, that is readily accessible across the city; beside electricity or wood, there is no other readily available energy source at scale in Lusaka.

Consumers, sellers, transporters and manufacturers are interconnected in a "treadmill of production" which can work against change where there are sunk investments or where change would shift benefits and costs for different actors. For instance, charcoal sellers would not necessarily sell an alternative "clean fuel", and some would probably suffer a diminished livelihood if there is widespread shift to more efficient charcoal stoves.

This is not to say that any intervention to change household behaviour must altogether avoid impacts on these other actors and dynamics, since the benefits of doing so might outweigh the costs, at least at the macro-level. However, it is important to at least illuminate the distributional impacts as part of the decision-making process.

3.4 Reflections on a user-centred, generative research methodology

Understanding the dynamics of household choices about energy, and about practices such as cooking that are heavily shaped by cultural norms, is complicated. The results of this study show clearly that to understand people's desires and needs, as well as how these are determined (i.e. by what combination of material constraints, normative patterns, etc.), it is essential to consider a combination of both expressed desires – the things people say – and those which are unstated but expressed in other ways.

The generative research methodology used in this study revealed a wide range of useful information – for instance, about the availability and use of different energy sources, fuel consumption levels, how and where different fuels are purchased (including how much effort and money this costs and how these costs compare with other household expenditures), as well as whether households have access to finance when needed. It revealed important information about the cooking sequence, the way in which people interact with the mbaula stove in and around their homes, and how cooking practices and charcoal use fit into people's wider daily routines.

The field research also illuminated problems people experience with current practices, as well as their expressed preferences relating to cooking fuels and methods. Overall, the methodology adopted for this study was able to bring to light both explicit and tacit preferences. Further, the process of observation in parallel with a flexible, semi-structured interview process enabled deeper lines of enquiry to be pursued with interviewees as interesting behaviours were witnessed. This is valuable, since sometimes behaviours confirm what people say, while at other times they can appear contradictory.

Household purchasing is an example of the latter. While all interviewees expressed financial difficulties in paying a higher up-front cost for a new stove, many have in the past paid considerable amounts for cooking equipment (usually electrical stoves of some kind). This suggests that at some moments at least people may have the ability to pay more and have shown a willingness to do so.

Another very important example is the fact that interviewees were unlikely to explicitly raise any real problems they experience with the mbaula when asked directly, yet through observation and subsequent questioning it became clear there are in fact numerous problems people experience regularly and which they would willingly modify their practices to overcome if suitable alternatives were readily available.

The only explicit concern people raised about the mbaula was its high fuel use and associated high fuel costs. On the basis of both explicit and tacit expressions, this deserves to be considered as the highest priority households have when it comes to weighing up alternative cooking practices. However, as described, there are a range of other needs and desires which form part of people's decision-making.

In the present circumstances, where there are limited practical alternatives to the mbaula other than electricity, people are generally willing to bear the burdens of greater health impacts and lower utility in order to save money. Nevertheless, past practices and choices – for instance, electricity use – indicate that people are willing to change practices to enhance their cooking experience and alleviate some of these problems, provided the costs are manageable. Such examples show the value of the direct observation and interview process in tandem, since users themselves did not cognitively associate their difficulties with any deficiency in the mbaula stove.

The main limitation of our methodology is that it is resource-intensive. In practice, this means relatively few households were met. The degree to which these few households can be extrapolated to meaningfully reflect the wider community in which they live is an open question. In this study, one factor that gives some confidence in stating our results with some authority is the observation that many of the same patterns emerged across interviews, such that by the end of even a small number of households, very similar storylines were emerging. Had there been larger differences in expression between households, the issue of sample size would become more significant.

Alternative methodologies that rely, for instance, on surveys to extract stated user needs and preferences may be able to generate larger data sets (survey methods are less resource-intensive). However, the results of this study suggest that if used in isolation they are likely to give an incomplete understanding of household behaviour. Stated preference methods emphasize cognitive factors while diminishing the significance of physical or emotional factors that also shape human behaviour.

To better understand how people make choices and trade-offs about cooking and energy use, a research strategy which uses the type of generative research applied here in conjunction with, and as a precursor to, more factor-specific methodologies such as "stated preference" is likely to be more successful in generating important insights. Whereas stated preference methods pre-select a series of parameters that households are asked to trade off against one another, these may not always be grounded in local context and risk being an irrelevant framing of the problems experienced by people. Generative research can illuminate the parameters that are actually being traded off against one another, as well as some indication of how these trade-offs occur.

There remains, of course, a degree of interpretation required by the researchers, meaning that presentation of results is a subjective process. While true of all research (including quantitative methods), the generative methodology used here – which places researchers "inside" the process, observing households and deciding which behavioural observations are significant and which are not – is particularly dependent on subjective judgements. This can be overcome to some limited extent by the presence of several researchers, since it enables later discussion of behaviour and statements, as was the approach taken by this study. The results remain, however, open to interpretation.

Finally, as with any study of this kind, language and cultural barriers are always present. While not associated with this methodology specifically, it is important to recognize how these leave scope for misinterpretation or misunderstanding. The use of an interpreter never fully overcomes the language barrier. However, a methodology that combines observation and conversation, as used here, is arguably more likely to avoid such problems because lines of enquiry are approached in multiple ways. For instance, where verbal statements are matched with observed behaviours, this encourages greater confidence in the results. Where the different data sets do not appear to match, this enables further interrogation by the researcher, and is thus more likely to overcome any misunderstanding. This essentially allows the researcher to "triangulate" observed data using multiple lines of evidence.

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ANNEX 1: THE WIDER CHARCOAL ECONOMY

Household energy is part of a web of economic activity associated with the production, transport/distribution and sale of charcoal. Although charcoal is consumed mainly in urban areas, it is produced in rural areas, thus creating an economic link between rural and urban communities. Different stages of charcoal production, handling and sale provide livelihoods for different people. These features are important to understand because individual household practices and decisions are influenced by – and influence – this wider charcoal-mbaula complex, and it therefore needs to be borne in mind during the design of interventions that are intended to transform current practices in the name of livelihood improvement.

An in-depth study of charcoal production, trade and transport around Lusaka between 1998 to 2001 was undertaken by the CHAPOSA project (Chidumayo et al. 2001), while others have also examined various aspects of the wider charcoal economy (e.g. TechnoShare Associates 2007; Kammen and Lew 2005; Mulombwa 1998). Rather than duplicate these extensive earlier efforts, this annex adds our own modest observations and data about the functioning of the charcoal economy, collected during interviews in and around Lusaka, while also drawing on some of the key observations of these earlier works.

A1.1 Production

Chidumayo et al. (2001) provide an in-depth review of the charcoal economy in Lusaka, from its arrival as a household fuel in the 1940s (introduced by Angolan charcoal producers in the northern Copperbelt province) through to modern-day production and distribution, and its role in supporting rural livelihoods. They estimate there were around 9,000 charcoal producers in Chongwe district in 2000, equivalent to 6% of the district's population, with Chongwe supplying around a quarter of Lusaka's charcoal at that time.[21] Charcoal is the second largest economic activity in the Chongwe district after agriculture, and is a larger source of revenue for the rural economy than agriculture.

Although the government has introduced licensing requirements for charcoal production for sale, in reality the vast majority of wood harvesting and charcoal production is still informal. Producers either cut trees without a permit, or they circumvent the rules about cutting trees by cutting branches instead (a point made anecdotally by one interviewee). According to Chidumayo et al. (2001), less than 20% of producers surveyed claimed to have had a license, while the total license fees paid to the Forest Department in 2000 was equivalent to around 0.05% of the value of wood stumped to make charcoal.

Some estimates suggest that around 44% of the total wood consumed in the region is used for charcoal production (CEEEZ 2005), and charcoal consumption has been linked to non-sustainable consumption of wood:

> … a deforestation factor has been well documented. In Zambia, one full-time charcoal producer is capable of clearing 0.5 ha per year (Chidumayo, 1988). With increasing demand and as many people are entering into this venture as an economic activity, the hectarage cleared per year is indeed great. Due to this clearance, most of the forests around Lusaka have been deforested, such that the pattern of charcoal production and supply shifted from the western and north-western in the 1970's and early 1980's to the Central and Eastern of Chongwe District during the 1990's (Ibid.). (CDM Executive Board 2009).

[21] Other estimates suggest there could be some 60,000 people employed in the charcoal industry (CEEEZ 2005).

According to Chidumayo et al. (2001), some cleared land is subsequently used for cultivation, while around 30% is not. They also point to problems with expansion of deforestation due to charcoal production into national parks and other ecologically sensitive areas.

Mulombwa (1998) identifies particular tree species that are preferred for fuel wood and charcoal production based on their high heat content value,[22] though he also points out:

> Selectivity in woodfuel tree species has resulted in localized scarcities of the preferred species. However, due to continuously increasing demand for woodfuel and depletion of priority species, current-harvesting methods do not segregate on species and this situation has culminated in complete degradation of certain forest areas. Natural regeneration in these areas has become almost impossible (under current institutional arrangements and economic situation) because re-growths are rarely given a chance to develop into mature trees - some are cut immediately they start to show signs of stem rigidity and others are destroyed by late fires which are very common, especially in livestock areas and in areas under the slash and burn (Chitemene) system of agriculture. (Section 2.2)

Some studies indicate that conversion of forest wood to charcoal within typical earth kilns is highly inefficient, resulting in substantial energy losses. One study estimated that the kilns used for small-scale charcoal production were only 10% efficient, meaning only 10 tonnes of charcoal are produced from 100 tonnes of wood (Kapiyo 1996, cited in Mulombwa 1998), while Chidumayo et al. (2001) concluded this figure might be closer to 25% for the earth kilns around Lusaka. Whatever the precise figure, this means that charcoal users consume substantially more wood than fuel wood users to obtain the same level of energy.

A1.2 Trade and transport

Anecdotal evidence collected for this study indicated that charcoal is being transported into urban areas by two primary means:

- Individuals riding bicycles carrying several large bags of charcoal. Some interviewees suggested that a transporter on bicycle can ride for six to eight hours in order to reach urban markets.
- Trucks driving in much larger loads. Since these are capable of bringing charcoal from further afield, prices for the charcoal can be lower.

In addition to license fees for tree cutting, there are also conveyance fees associated with charcoal distribution to urban markets. The Forest Department requires traders to pay fees of 360 kwacha per standard bag containing approximately 41 kg of charcoal (Chidumayo et al. 2001), while there are suggestions that additional conveyance fees are extracted from charcoal traders by the Chongwe District Council (ibid).

Both bicycles and trucks make efforts to avoid paying the transportation fees. Interviewees suggested many bicycle riders enter the city area via small trails through the bush, in order to avoid the levy. Several indicated that some of the charcoal trade involves members of the police and politicians, and these people arrange for trucks to enter without paying the levy, often arriving to the city during the night. According to Chidumayo et al. (2001), more than half the trucks bringing charcoal into Lusaka arrive during the night.

[22] These include (tree names in Bemba language given in brackets) Julbernardia paniculata (Mutondo), Julbernardia globiflora (Sandwe), Brachystegia boehmii (Musamba), Brachystegia spiciformis (Muputu), Bauhinia thoningii (Musekese), Pericopsis angolensis (Mubanga), Parinari curatellifolia (Mupundu) and Uapaca kirkiana (Musuku) (Nkomeshya 1996, cited in Mulombwa 1998).

One charcoal producer interviewed stated that he pays bicycle riders 5,000 kwacha per bag to take his charcoal to the city if he cannot sell it locally.

A1.3 Market dynamics

Of the charcoal found in urban Lusaka, Kalumiana (1997) found that around 59% originated from Central Province and 13% from Copperbelt Province, specifically Ndola Rural District. Export of charcoal from these other regions of the country to Lusaka is driven by higher market prices in the capital.[23] As mentioned, Chidumayo et al. (2001) also point to Chongwe as an important source.

In terms of purchase sites for consumers, around 60% of charcoal is obtained at municipal markets, followed by around 30% through homestead traders (Kalumiana 1997). Roadside sellers and hawkers make up each less than 5% of overall charcoal sales. Different income groups have different patterns for purchase, with high-income groups having higher-than-average reliance on both municipal markets (82%) and roadside sellers (11%). Low-income groups rely more heavily than average on homestead traders (42%).

Market prices for charcoal vary along the chain between production and end use. Observations during our field work found the following:

- A *charcoal producer* off Leopards Hill Road (to the east of Lusaka) sells 50 kg bags to a nearby military barracks for 20,000 kwacha. He indicated that if he instead transports the charcoal into Lusaka it costs him around 5,000 kwacha per bag in transport costs; hence his preference is to sell to the local market if possible.
- *Roadside sellers* outside Lusaka, on the Great North Road and on the road south of Kafue (between Kafue and Churindu), were selling 50 kg bags for 25,000 kwacha. On the Great North Road, sellers indicate that they buy a truckload of large bags of charcoal which comes from further away. Bags are bought for 70,000 kwacha each and resold for 75,000 kwacha.
- Lusaka *municipal market* prices were checked in various points around Lusaka, including Mtendere, City, Soweto and Kabwala markets. Small bags were sold for 1,000, 1,500 and 2,000 kwacha. A 15 kg bag typically costs 15,000 kwacha, a 25 kg bag costs 20,000 kwacha, a 65 kg bag costs 65,000 kwacha, a 75 kg bag costs 75,000 kwacha and a 90 kg bag costs around 80,000 to 90,000 kwacha.
- *Household* interviewees indicated that during the dry season the standard price at municipal markets for a 1 kg bag is 2,000 kwacha. However, for larger bags there was considerable variation in the prices quoted by different interviewees. A 50 kg bag ranged from 55,000 to 95,000 kwacha. Charcoal prices increase significantly during the rainy season. One interviewee noted that a 5 000 kwacha bag doubles in price to 10,000 kwacha, while a 25 kg bag can cost 35,000 to 40,000 kwacha and a 50 kg bag can cost between 120,000 to 150,000 kwacha. Another noted that a rise in charcoal prices occurred at the same time as electricity tariffs were increased during 2010, at which time "a 3,000 kwacha bag rose to 5,000 kwacha".
- Selling charcoal can be an important source of income for some urban households. Several interviewees buy large bags then repackage and resell the charcoal in smaller bags which retail for a higher price per kilogram. Small bags of 1 kg typically sell for 2,000 kwacha.

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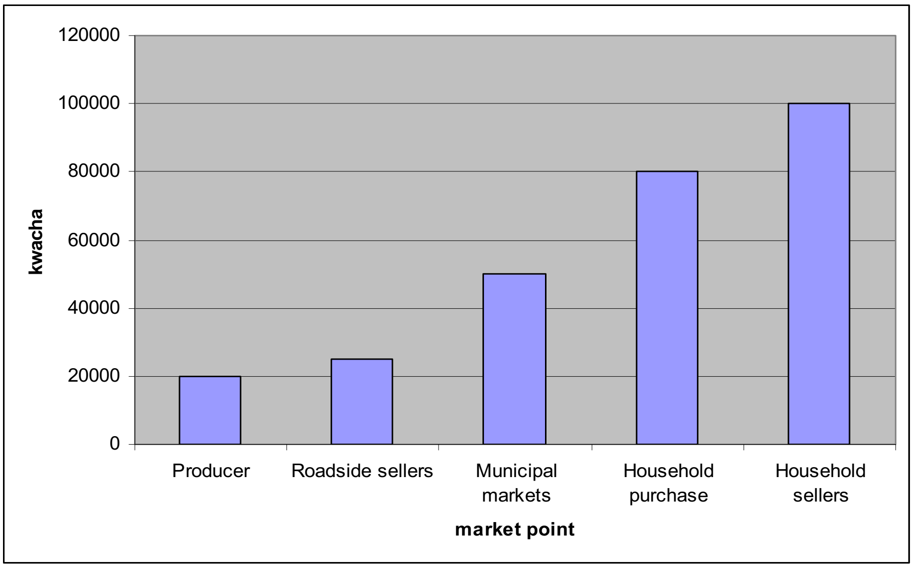
[23] Charcoal prices in December 1996 were on average 30% higher in Lusaka than the highest price on the Copperbelt (Kalumiana 1997).

The price variation along the market chain, illustrated in Figure A1, highlight that each one of these steps between producer and end user represents a livelihood for different groups of people. Thus, any future reduction in charcoal demand will have economic implications for these groups.

Figure A1: Quoted charcoal prices at different market points for 50 kg of charcoal



For households, charcoal purchase behaviour depends on cash flow situation. If they have money it appears most opt for buying larger bags of charcoal, which means fewer visits to the market and cheaper per unit fuel costs. If they have little money, households can only buy small 1 kg or 2 kg bags of charcoal which typically last about one day. In some cases cash flow is so tight that households buy small charcoal bags twice a day. Since smaller bags cost significantly more per kilogram, overall expenditure on fuel therefore increases during times when households have less money, both in net and relative terms. In the figure, the additional cost to households with low cash flow is seen in the difference between the columns labelled "municipal markets" and "household sellers".

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