4. Energy and the environment in Sub-Saharan Africa

Household perceptions of improved cookstoves

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4.1 Introduction

Globally, 2.7 billion people rely on solid biomass fuels like fuelwood, charcoal, animal dung, grass, shrubs or agricultural residue to meet their cooking and heating needs. In Sub-Saharan Africa, 80% of households rely on biomass and many people cook on open fires inside their homes. As well as being fuel inefficient, household members - especially women and children - are exposed to harmful levels of wood smoke (Bruce et al. 2000, 2015). Analysis of data from the 2010 Global Burden of Disease study (Lim et al. 2012) identified household air pollution (HAP) arising from the burning of solid biomass fuels as the second most common cause of death in eastern, central and western Sub-Saharan Africa. The same study identified HAP as the third most important risk factor globally (second for women), causing an estimated 3,478,773 deaths annually and contributing 4.3% of global disability adjusted life years (DALYs). They key causes of death linked to HAP include chronic respiratory diseases, heart disease, childhood pneumonia, cancers, cataracts, and burns (GACC, nd, IEA and World Bank 2015).

4.1.1. The evolution of improved cookstove initiatives

Improved cookstoves (ICS) designed to burn biomass fuels more cleanly and efficiently have been promoted by charities, governments and private sector actors in low-income countries since the late 1940s. Some of the earliest designs sought to reduce smoke (Smith 1989, Sesan 2014) but by the early 1970s, concerns about fuelwood shortages causing deforestation (Eckholm 1975) hel-

ped to focus attention on more fuel-efficient stoves (Barnes et al. 1994). At the same time, attention focused on the gender implications of a reliance on biomass for cooking and heating as gender divisions of labour often give the responsibility for biomass collection to women and girls. This can involve them in spending many hours per day undertaking such work which can in turn compromise their access to education and the development of skills needed for a variety of income generating activities (Agarwal 1986). Following critiques of the scale of fuelwood-related deforestation, however, attention gradually re-focused on the health and gender impacts of cooking with biomass (Hanbar and Karve 2002, Nagothu 2001, Sesan 2014). More recently, concern has grown about the climate change impacts of traditional cookstoves given that they are estimated to emit a third of global carbon monoxide along with significant emissions of black carbon (soot), nitrous oxide, methane and non-methane volatile organic compounds (Rosenthal 2009, Venkataraman et al. 2010). This helped to consolidate a shift towards emphases on the use of "clean" fuels and cookstoves with potential to offer global environmental and health benefits (Hanbar and Karve 2002, Nagothu 2001, Simon 2010, Sesan 2014).

To an extent, this reflects the underlying assumptions of the "energy ladder" model that household fuel preferences shift, with increasing income, from a reliance on biomass fuel to transitional fuels such as kerosene and later to cleaner and more efficient fuels such as gas or electricity (Bruce et al. 2000). Nevertheless, a number of empirical studies have questioned the model, highlighting the low priority given to the adoption of modern fuels given competing household economic priorities and the ways in which households often combine (or "stack") different fuels in different seasons in order to undertake different types of cooking (Masera et al. 2000, van der Kroon et al. 2013, Ruiz-Mercado and Masera 2015, Treiber et al. 2015).

4.1.2. Recent initiatives promoting clean fuels and cookstoves

Despite a plethora of interventions, however, the adoption and sustained use of clean and improved cookstoves remained low globally, prompting the establishment, in 2010, of the Global Alliance for Clean Cookstoves (GACC) which seeks to "foster the adoption of clean cookstoves and fuels in 100 million households" by 2020 (GACC, 2017a). To this end, GACC promotes the use of the International Working Agreement's (IWA) stove tier system which sets out guidelines for rating stoves according to their efficiency/fuel

use, safety, indoor emissions and total emissions. As with the energy ladder, there is an assumption that increasing socio-economic status encourages households to make a linear transition to the use of higher tier stoves (GACC 2017b; Ray et al. 2017)

Working alongside GACC, Sustainable Energy for All (SE4ALL) has focused on including energy in the post-2015 global goals and making efforts to meet the UN General Assembly's key targets to "ensure universal access to modern energy services, double the global rate of improvement in energy efficiency and double the share of renewable energy in the global energy mix" (IEA and World Bank 2015: 38). As part of this role, SE4ALL has collaborated with the Energy Sector Management Assistance Program (ESMAP), IEA and World Bank to prepare indicators for Sustainable Development Goal 7 (SDG7) which seeks to "ensure access to affordable, reliable, sustainable and modern energy for all" by 2030 (UN, 2016a). Echoing historical variations in the thrust of earlier cookstove interventions, SE4ALL and GACC have respectively emphasized how "non-solid fuels"[1] and clean cookstoves can provide health gains, improve fuel use efficiency and wider environmental benefits associated with lower levels of greenhouse gas emissions and forest decline (Lewis and Pattanayak 2012, Bielecki and Wingenbach 2014).[2] Recognizing the gender implications of a reliance on biomass fuels, GACC has also linked low levels of female empowerment to the failure to include energy in the Millennium Development Goals (GACC, nd).

SE4ALL, meanwhile, has been instrumental in developing a "global tracking framework" (GTF) to provide baseline data for SDG7 targets in terms of access to "modern cooking solutions" (IEA and World Bank 2015:

1 Solid fuel use (e.g. wood, crop residue, dung or charcoal) in low-income countries has been linked to inefficient combustion and negative health impacts while the use of non-solid fuels such as biogas, LPG, electricity, ethanol, natural gas and solar energy (BLEENS) is associated with more efficient and cleaner, healthier cooking practices (IEA and World Bank, 2015). Although kerosene is classed as a non-solid fuel, it tends to be excluded from this group of more desirable fuels because of the pollution it causes as well as the risk it presents in terms of burn-related domestic injuries.

2 GACC's target of clean cookstove adoption by 100 million households (of the estimated 2.9 billion that rely primarily on solid fuels – GTF 2015), echoes the target of Millennium Development Goal (MDG) 7C to halve the proportion of the population without sustainable access to basic sanitation which was criticised for focusing on promoting uptake among the "low hanging fruit" of higher income with no previous sanitation access.

48) and the "percentage of population with primary reliance on non-solid fuels" (IEA and World Bank 2015: 3). These data suggest that the number of solid fuel users globally rose from 2.8-2.9 billion with significant inequalities in access to non-solid fuels (5% and 40% respectively) between poorer and wealthier groups (IEA and World Bank 2015: 55-56). Unlike the GTF, however, SDG indicator 7.1.2 which tracks the "proportion of population with primary reliance on clean fuels and technology" (UN 2016b) makes no reference to either non-solid fuels or cooking. SDG7's retention of the GTF's focus on tracking "primary reliance" on cooking fuels and technologies, meanwhile, discourages data collection on whether households use of a range of different fuels (stacking) in order to adjust to factors like fluctuating fuel prices, seasonal fuel availability or changes in the number of people they are cooking for (Masera et al. 2000, Ruiz-Mercado et al. 2011, Rehfuess et al. 2014, Ruiz-Mercado and Masera 2015, Loo et al. 2016, Lozier et al. 2016).

4.1.3. Neglect of end-user preferences

Despite emphases by GACC and SE4ALL on the environmental, health and gender benefits associated with clean fuel and cookstove use, end-user perspectives continue to be marginalized and there has been limited evidence to date of the use of participatory approaches to either better understand barriers to the adoption of clean fuel and cookstoves or promote their use. According to Sesan (2014: 6) initiatives promoting more efficient cookstoves in the 1970s and 1980s were characterized as a "straightforward technical challenge" with limited end-user engagement. From the 1990s, emphasis within the stove sector shifted towards more commercially-oriented initiatives producing efficient but often unaffordable stoves lacking key features prioritized by end-users (Simon 2010, Sesan 2014, Jewitt and Rahman 2017).

A common feature of improved cookstove initiatives has been the use of more quantitative, techno-centric approaches that produce highly efficient stoves that lack key functions required or desired by their end-users (IEEE 2014, Ray et al. 2014, 2017). This has occurred despite the weak relationship between socio-economic status and the use of biomass for cooking pointing to low levels of demand for "clean" or "efficient" stoves and strong user preferences for solid fuels (IEA and World Bank 2015: 63). After all, in areas where solid fuel can be gathered free of cost, stoves that require fuel to be purchased are unlikely to be attractive given other demands on household budgets.

Efforts to address similar constraints in the sanitation sector ("free of cost" open defecation versus costly sanitation systems), also met with frequent failure when technology-oriented initiatives were employed in areas with low demand for latrines. This prompted the development of social marketing approaches, participatory community-led "total sanitation" initiatives (CLTS) that proved far more successful in stimulating sanitation uptake (Kar 2003, Evans 2005, Kar and Pasteur 2005, Jenkins and Sugden 2006, Jenkins and Scott 2007, Peal et al. 2010, O'Reilly and Louis 2014, Arickal and Khanna 2015).

Common examples of participatory tools used in CLTS include social mapping exercises to identify commonly used open defection (OD) sites and transect walks to illustrate faecal-oral transmission routes between OD and food preparation sites. These are supported by community-designed mechanisms such as regular monitoring of OD sites to create social pressure to maintain this behaviour. This is important in helping to promote the realization that individual wider environmental health benefits can only occur if change occurs at the community level (Kar 2003, Kar and Pasteur 2005). Until quite recently, however, evidence of such approaches being used for cookstoves has been limited (Graham 2015, Rosenbaum 2015).

4.1.4. Limitations of fuel and ICS monitoring

Compounding the drawbacks associated with poor end-user engagement in cookstove promotion initiatives is a tendency for existing fuel and cookstove use monitoring mechanisms to ignore the complexity and fluidity of household energy use. In contrast to the energy ladder's assumptions of upwards progress in a linear manner, families are just as likely to move "down" the ladder in response to rising prices for their primary cooking fuel (IEA and the World Bank 2015). Their "primary" fuel use may also vary seasonally in response to changes in weather or resource availability while the importance of fuel or stove "stacking" (Masera et al. 2000) is unlikely to be captured using current monitoring approaches.

Reflecting these shortcomings, improved cookstove (ICS) interventions and monitoring systems have been criticized for failing to understand the complex ways in which household cooking systems are embedded in local cultures and livelihoods (Ruiz-Mercado et al. 2011, Ray et al. 2014, Sesan 2014, Ruiz-Mercado and Masera 2015). At the same time, there is increasing recognition within the ICS literature of the need to understand and respond to

the priorities and preferences of end-users (Beyene and Koch 2013, Kohlin et al. 2011). Increasingly, research has called for the greater use of qualitative, participatory methods to explore the non-technical dimensions of ICS dissemination and understand socio-economic and cultural factors affecting fuel and stove choices (Ray et al. 2014, 2017).

4.1.5. Research problem and contribution

Drawing on participatory "bake/cook-off" events in the UK, Malawi and Zambia plus empirical evidence from Benue State, Nigeria, sections 3 and 4 of this chapter provide insights into how context-specific end-user priorities coupled with constraints associated with different settings often inhibit a linear shift towards sustained use of one clean cooking system. Attention is drawn to how cooking practices, preferences and taboos tend to vary over space with factors such as socio-economic status, environmental change, cultural norms associated with cooking, fuel availability/cost, family size, ethnicity, age or gender often having a significant influence on both household energy preferences and whether a particular fuel or cookstove is likely to be accepted and adopted. Particular emphasis is placed on how households understand and access environmental resources in order to meet their daily energy needs and why many still prefer to use solid biomass for their cooking needs; especially where it can be gathered free of cost.

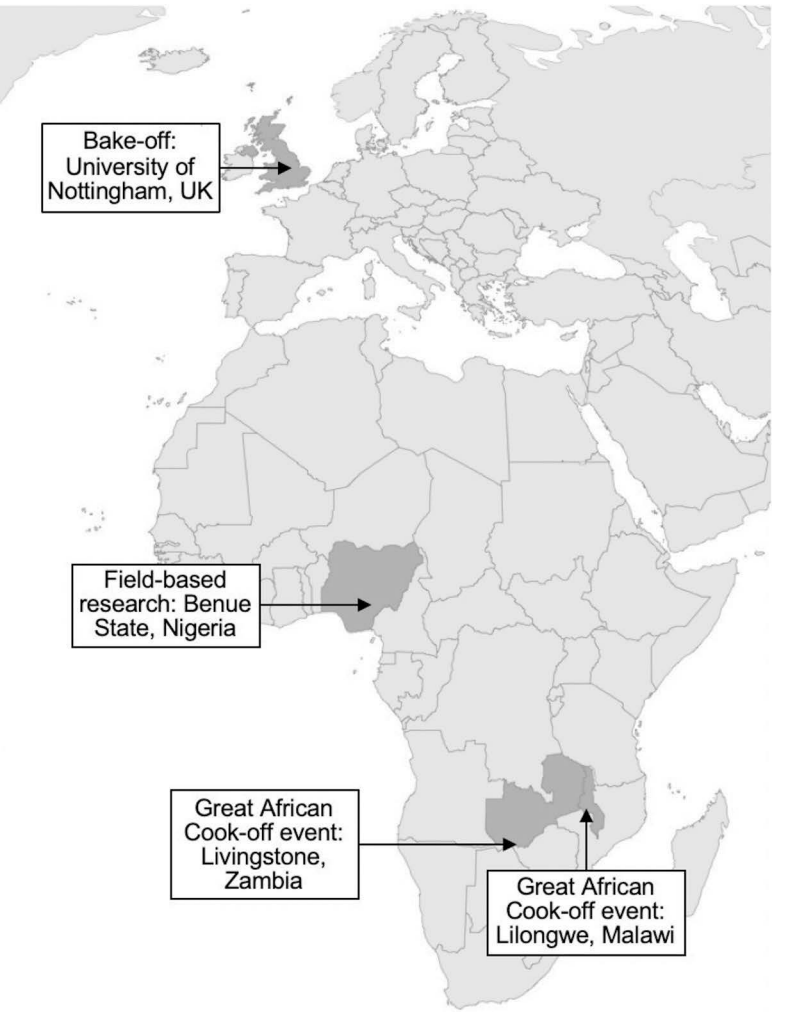
The chapter's originality and rigour lies in its use of qualitative methods along with participatory approaches to obtain end-user priorities for cooking fuels and technologies in contexts where households commonly use a range of different systems and make frequent shifts between them. Its significance lies in its emphasis on the need to develop participatory approaches that will help to improve monitoring and better understand end-user preferences and engage them in ICS design, production and dissemination initiatives.

4.2. Methodological approaches

A range of qualitative methods and participatory approaches were utilized in this research as a means of developing innovative approaches for sharing interdisciplinary academic and user-based perspectives on "improved" cookstove and household energy systems. Phase one was associated with a series of "bake/cook-off" events to elicit end-user perspectives on a range of ICS while

phase 2 involved in-depth field-based research on cooking practices and priorities in Benue state, Nigeria (see Figure 1).

Figure 1: Map of bake/cook-off events and field-based research



4.2.1. Bake/cook-off events

The bake-off event that took place at Nottingham University in September 2015 was attended by volunteers from the Nottingham Women's Cultural Exchange, academic researchers, development practitioners and policy makers. The volunteers came from a range of African countries (including Nigeria, Eritrea, Sudan, and Malawi) and all had previous experience of cooking with biomass fuels. At the event, a range of improved cookstoves were made available and the volunteers were invited to cook typical food from their home countries on their chosen stove and share their experiences of using this stove with the workshop attendees. A key aim of the bake-off was to create opportunities to observe different ICS in action and how end-users interact with them as a means promoting discussion and enhancing understandings of user preferences, performance, safety and wider cultural (especially gender) considerations surrounding energy/fuel choice.

To encourage broader discussions about the different technologies used at the event, a range of participatory exercises were used to help volunteers and attendees to identify and discuss what they liked and disliked about the different stoves and compare views. This in turn led to fruitful discussions about how differences in priorities between policy makers, stove manufacturers and end-users could impact on the adoption and sustained use of ICS.

The "bake/cook-off" format was adapted for use in Malawi in March 2016 as part of a "Great African Cook-off" event at the Cleaner Cooking Camp Conference[3] which brought together national and international stove enthusiasts to discuss challenges around clean cooking in Malawi and test a range of stoves for end-user acceptability. As with the Nottingham bake-off, this event provided a designated space for attendees to interact with participating cooks and was attended by a range of stakeholders including government, donor organizations and INGOs as well as the Malawian Minister for Energy. Later in 2016, a second "Great African Cook-off" event took place in Livingstone, Zambia, where members of the public, stove producers, policy makers and charitable organizations gathered to share knowledge and learn about rocket stoves, solar cookers, imported gasifier stoves, improved charcoal burners and handmade clay rocket stoves. As insights gained from the Nottingham event played a key role in shaping the research questions and methodologies used

3 This annual event is supported by the National Cookstoves Steering Committee and led by the Energizing Development Programme (EnDev).

in the field-based research in Benue, these will be discussed in more detail below.

4.2.2. Field-based research in Benue State

Benue state was chosen as a location for the field-based research on the basis of the high but declining level of dependence on wood as a domestic cooking fuel coupled with one of the author's familiarity with the area and his ability to speak Tiv. From the perspective of undertaking participatory research, this author's role as an "insider" as well as an "outsider" (born and raised in Benue state but educated overseas and undertaking research in Benue) placed him in an excellent position to mediate between "outside" researchers and local community members (Mosse 2008) whilst translating the research agenda into a methodological approach that engaged participants. At the same time, his familiarity with local socio-economic and cultural norms helped in gaining access to local community members and building trust; eliciting, in the process, information regarding changes in local cooking practices and preferences and the cultural norms surrounding them. Local knowledge of wider policies affecting fuel and stove availability, seasonal weather patterns, their influence on employment opportunities and associated rural-urban migration rhythms were also important for planning appropriate times for undertaking different elements of the research. The "outsider" perspectives of other team members and bake/cook-off participants, meanwhile, helped to ensure that research questions and methodological approaches arising from these events along with shortcomings associated with broader fuel and cookstove dissemination and monitoring trends could be addressed by the methodologies employed in the study sites.

Benue is located in north-central Nigeria and has an estimated population of 4 million in an area of 30,800 km^2. The dominant ethnic groups in Benue are the Tiv with around 69% of the population followed by the Idoma and the Igede which make up around 23% of the population (NBS/CBN/NCC 2011). According to Ali and Victor (2013), socio-economic development in the state is strongly dependent on the charcoal and firewood trades. Dapo and Emmanuel (2013) found that the majority (76.7%) of households that used charcoal as a cooking fuel spent an average of N3310[4] on this monthly, while 23.3 percent of households spent N2394 monthly on alternative cooking fuels. Firewood

4 At the time of the research, £1 was N396

and charcoal are more readily available in the state than kerosene so there are competing demands for these fuels for cooking and other exigencies. Both fuels can be purchased from roadside traders although many households are willing to travel several kilometres to collect firewood for free.

In order to provide to help with the selection of sites for community-based data collection, state-level data from the 2008, 2010, 2013 and 2015 Demographic Health Surveys (DHS) for Nigeria were obtained and information on the type of fuels household mainly use for cooking was analyzed for rural and urban areas of Benue using SPSS. This revealed that in 2008, 93.4% of households used wood as their main cooking fuel with 4.5% using kerosene and 0.3% using charcoal. A very small number of households used natural gas but none reported electricity or Liquefied Petroleum Gas (LPG) as their main cooking fuel in the 2008 survey. Subsequent surveys revealed a slight decline in the use of wood as the main cooking fuel (92% in 2010, 88.2% in 2013 and 79.1% in 2015) while kerosene use rose slightly before declining (6.5% in 2010, 8.5% in 2013 and 6.6% in 2015) and charcoal use increased (2% in 2013 and 6.2% in 2015) along with natural gas (negligible in 2010 and 1.4% in 2015)

DHS data also revealed significant variations between rural and urban areas, however, with 42% of urban households relying on wood, 44% relying on kerosene, 7% on electricity, 5% on charcoal and 2% on LPG as their main cooking fuel compared to 84% relying on wood, 10% on kerosene, 5% on electricity and 1% on charcoal in rural areas. According to surveys conducted by the National Bureau of Statistic (NBS), Central Bank of Nigeria (CBN) and National Communication Commission (NCC) conducted across Nigeria in 2010, urban households spend an average of N970 and N1233 per month on firewood and charcoal (NBS/CBN/NCC 2011).

Information was obtained from three sites chosen on the basis of their contrasting fuel availability. Site 1 is an urban community within the state capital, Makurdi, where LPG, electricity and charcoal are available in addition to fuelwood. LPG is available from a gas refilling plant where a 10kg cylinder can be refilled for N1800. The cost of gas stoves ranges from N12672 to N93000 while a two burner electric stove costs N21,000. Demand for firewood here has increased as a result of brick-making activities in the area which has forced up prices. The town's proximity to the state capital coupled with the presence of a gas refilling plant has enabled some households to access to ICS and modern fuels such as electricity and gas thus providing useful insights into the value attached to ICS and modern fuels compared to more "traditional" cooking systems. The presence of a brewing company has encouraged in-migration

for employment purpose which has in turn stimulated the development of a range of food restaurants which - in the absence of large capacity improved cookstoves - cater for the town's population using wood on open fires as their key fuel. Restaurant owners along with many local residents travel several miles outside the community to collect free firewood.

Site 2 is a peri-urban community with a long-standing reliance on firewood as the primary cooking fuel. Firewood is purchased from communities across the river and transported by canoes. Households that do not have the economic resources to purchase firewood travel several kilometers outside the community to gather it free of cost as local woodland areas have been exhausted. Most households prepare meals on three-stone fires placed outside their dwellings although some make additional use of kerosene and "Abacha" stoves which are usually constructed of steel and use charcoal as their primary source cooking fuel.[5] Kerosene stoves cost around N8000 compared to N3000 for an Abacha stove.

Site 3 is a rural community and households travel shorter distances to obtain their cooking fuel as they have access to state-managed plantations. Livelihoods are dominated by trading and the processing of farm produce although fuelwood selling is also widespread. Although some households own gas, kerosene and Abacha stoves, many have reverted to using three stone fires to reduce the costs of purchasing fuel. Restaurant owners here cook on three-stone fires rather than improved stoves as they consider the former the best option for cooking large quantities of food.

4.2.3. Field-based methodologies

The research was conducted in two phases with findings from the pilot phase being used to refine the research questions. The targets of the community-based research were households from different socio-economic and ethnic groups in the three study sites that used a range of different fuel and cookstove types. The study employed household surveys, focus group discussions, participatory appraisal tools and direct observation to understand decisions and preferences relating to cookstove and fuel use in the context of broader household socio-economic priorities. Participants that took part in focus group discussions during the pilot phase were later re-visited to enable more

5 Abacha stoves were introduced in Nigeria in 1994 by the Military Head of State General Sani Abacha in response to kerosene shortages and resulting price hikes.

detailed information on household cooking practices and preferences to be obtained. In order to gather gendered perspectives on household energy and cooking preferences, data was collected by both male and female researchers.

Drawing on emphasis by Ruiz-Mercado and Masera (2015) on the need to understand the cultural dynamics driving households' fuel choices and cooking device priorities, focus group discussions and participatory exercises were carried out with 49 (14 male, 35 female) participants. At the same time, participatory ranking exercises were undertaken to provide understandings of where stove and fuel choice sat within broader household priorities and aspirations. In each study site, 21 household surveys were undertaken to obtain information on household demographics, existing fuel and stove use, fuel and cooking preferences and perceptions of different stove features. At the same time, household observations were carried out and fieldnotes were taken in order to obtain complementary data for comparison across the sample categories.

Semi-structured interviews were undertaken with 3 male community elders in each study site to elicit information on existing cooking practices and the extent to which these have changed over time. Two (male) stove artisans were also interviewed to elicit information on State government strategies and policy support programmes (if any) for developing the sector. Additional elite interviews were carried out with government employees in relevant Ministries. At the state level, the Director of Forestry in the Ministry of Environment and Urban Development, Benue State, was interviewed to explore programmes related to ICS interventions and energy policy in Benue. At the national level, interviews were conducted with a scientific officer within the Energy Commission and with a director in the Ministry of Women's Affairs and Social Development as both had responsibility for implementing energy-related policy decisions. Qualitative data derived from these methods were transcribed and exported into NVivo 10, coded and analyzed qualitatively, using thematic analysis to group emerging themes. Quantitative data from the household surveys were coded in Microsoft Excel 2013 and analyzed with a zero non-response.

4.3. End-user priorities for cooking systems: results from the bake/cook-off events

All three bake/cook-off events were highly participatory in nature as they focused around end-users identifying criteria that they associated with "improved" cookstoves and then choosing one or more ICS to prepare food on (see Figure 2).

Each event then provided opportunities to use a range of improved cookstoves with a key theme being the sharing of multi-disciplinary and user-oriented perspectives on what is understood as an "improved" cooking or household energy system. At the Nottingham bake-off the range of different stoves in use and on display and the food being cooked provided foci for the discussion and elicited a range of questions from participants including academics with different disciplinary backgrounds (engineering, science and technology studies, education, psychology, human factors, business, nursing, health sciences, sociology, development studies, geography, built environment), members of the public, development practitioners, NGOs and policy makers.

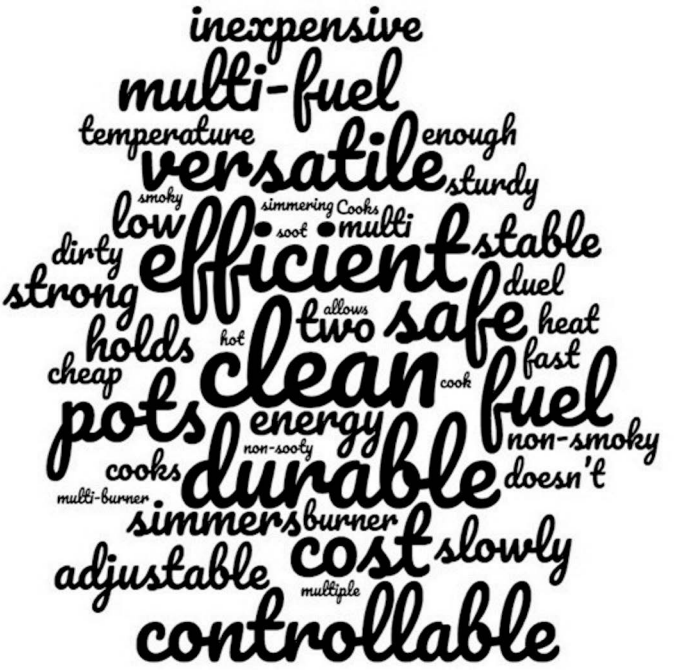
The fact that participants were able to experience key stove characteristics first hand (e.g. smokiness, controllability, stability, cooking speed, fuel efficiency etc.) was enormously effective in enhancing understandings of the advantages and constraints associated with using different stoves while discussions with cooks on their cooking experiences provided important insights into wider socio-cultural practices surrounding household energy use in energy-poor low-income country contexts.

At the end of the bake/cook-off sessions, participants were asked to note down their observations about the different stoves they viewed in operation as well as an additional selection of stoves that were left out for viewing but not lit. As a key emphasis was to collect views from a range of disciplinary and stakeholder perspectives, they were not provided with any guidance on how to structure their comments. Key observations focused around affordability, safety (especially linked to re-fuelling mechanisms but also stability-related issues), smokiness (especially in confined spaces), efficiency, durability, controllability and versatility (see Figure 3)

The cooks, meanwhile, were asked to re-visit the criteria they associated with ICS and then undertake a participatory ranking exercise to examine the performance of each stove according to these different criteria. As part of this process, they were encouraged to discuss wider cultural (including gender) considerations surrounding energy/fuel preferences and share experi-

Figure 2: Great African Cook-Off in Malawi. Picture: Charlotte Ray and Maria Beard

Figure 3: Word cloud of participant observations from the Nottingham bake-off



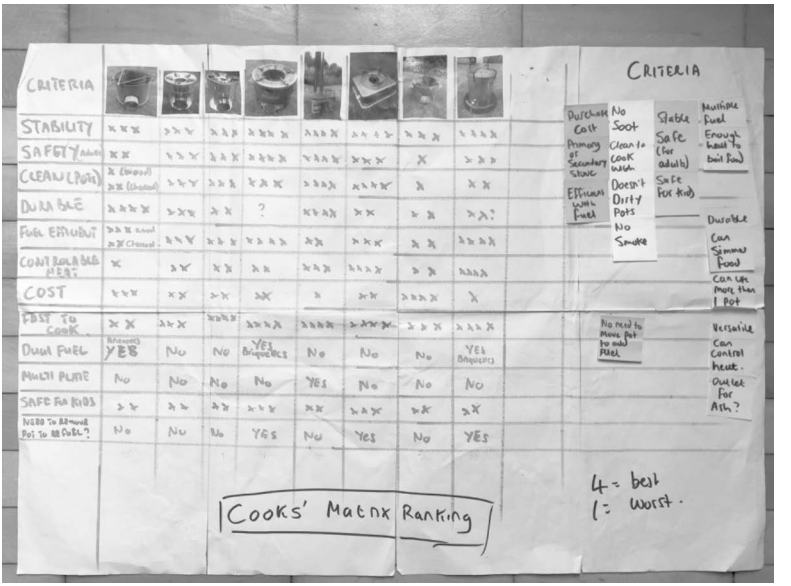
ences regarding variations in user priorities in different socio-economic and cultural settings. As can be seen from Figures 3 and 4, many of the criteria identified prior to the bake-off remained the same, but having used the different stoves, a number of additional criteria were identified for the matrix ranking exercise (see Figure 5). At the Nottingham bake-off, these focused mainly around safety issues including stability and burn-related risks for adults (linked to lighting and re-fuelling the stoves) and children. Criteria linked to controllability, versatility and cleanliness, meanwhile, increased in importance as a result of widespread admiration among the cooks for the EcoZoom La Plancha Stove with dual hotplates and an oven, the Ace 1 stove with a USB charger and the Clean cookstove which offered controllability and did not dir-

ty the cooking pots. These user-preferences are reflected in the final matrix ranking in which the La Plancha and Ace stoves scored the highest on usability-related criteria by the cooks but were considered expensive (around £320 and £130 respectively) so received low scores for cost.

Figure 4: Word cloud of participant observations from the Nottingham bake-off

Discussions of stove "stacking" also took place as the cooks debated which stoves were best for cooking different types of food along with external influences (e.g. rules associated with living in rented accommodation) on the types of cooking systems that could be used. Other interesting observations that arose from discussions between cooks and with participants focused around how easy the different stoves were to light, how quickly they reached cooking temperature and the ease with which they could be re-fuelled. The latter

Figure 5: Cooks' matrix ranking from Nottingham bake-off



discussions were particularly interesting as they brought to light concerns associated with taking the pot off the stove to add fuel. Some cooks discussed the safety implications of removing a pot full of hot liquid to add fuel while others mentioned that removing the pot from the flame is regarded as taboo in some cultural contexts.

Accounts from different domestic settings, meanwhile, indicated that household members with responsibility for cooking, fuel gathering and cleaning dirty pots often had little control over domestic budgets so in the absence of serious health problems, changes would be unlikely to occur. In the Nottingham bake-off, where the cooks mostly had a background as refugees or asylum seekers and had become used to using electric or gas cookers in the UK, the smokiness and dirty pots produced by the charcoal and fire-wood fuelled stoves were a greater concern than it was the case in the Malawi and Zambia cook-off events where the cooks had less exposure to non-solid fuels. These observations along with those of the workshop participants were later transcribed and used to inform the content of the

household surveys, semi-structured interviews, focus group discussions and participatory tools used in the Benue fieldwork.

4.4. Community-level perspectives on cooking systems and fuel choices in Benue

The main period of fieldwork in Benue took place over a period of six months between December 2015 and May 2016 although a pilot phase was undertaken in Spring 2015 with the purpose of making contact with the proposed study communities, piloting the household survey and undertaking some focus group discussions to identify key issues relating to fuel and cookstove use and preferences in the different sites.

4.4.1. Class and gender as influences on ICS and fuel use

Echoing GTF data indicating low uptake of non-solid fuel use by low-income groups (IEA and World Bank 2015), financial constraints were highlighted in the study sites as a key influence on cooking system choices, although broader cultural influences, such as Tiv traditions of hospitality, sometimes intersected these choices. Aside from a reliance on three stone fireplaces when catering for social gatherings or large family sizes, group discussions indicated that low-income groups tended to use three stone fireplaces with firewood while the use of clean cooking technologies such as gas and electric stoves was more pronounced amongst higher income groups.[6] As one low-income householder mentioned:

> "We have limited resources … so we predominately cook with firewood" (Interview two: Site 2, 2015).

In addition to income status, gender has an important influence on decisions about stove and fuel choice in the study sites with men tending to defer to women in recognition of their responsibility for household food preparation. As one female respondent noted:

6 Income groups in the study sites were identified using a range of indictors including number of income-earners in the household, their approximate income levels and key household expenses including the average cost of household energy.

> "My husband understands that I am the one who is always in the kitchen and would be in a better position to understand my needs so when I ask him to purchase anything in the kitchen including a stove he quickly obliged" (Focus group one: Site 3, 2015).

This view was also echoed by most male focus group participants who indicated that decisions of stove purchases would be largely in the hands of women; even at the point where requests for household finances were made. As two male respondents noted:

> "A woman … ordinarily she is the cook and our culture is such that she is the 'commander' in the kitchen so whatever she said at any moment is the last order and the husband has to obey, so the decision rests with the woman" (Focus group one: Site 1, 2015).
> "Cooking duties are exclusively reserved for women and men are strongly forewarned to stay clear of cooking" (Interview two, Site 2, 2015).

One negative impact of women's responsibility for stove and fuel choices is that they also tend to have responsibility for collecting fuel for these stoves. This often involves significant drudgery and when men often get time to relax after returning from the fields, women often have to go in search of fuelwood and water to enable them to fulfil their domestic responsibilities. This is particularly burdensome for families that have to travel long distances to collect fuelwood.

4.4.2. Access to firewood

Firewood availability was mentioned as a particular constraint in Site 2 although interestingly, this was not linked to deforestation but rather to the conversion of former forest and bush land into farmland. A consequence of this was that household members now have to travel up to 6km to collect free fuel and there were many complaints of firewood collection having become very "time-consuming" and "a tedious process" (Focus group two: Site 2, 2015). Respondents reported that:

> "Since firewood around the community has been exhausted we travel to the hinterland covering 10km each trip. Although each of the journeys is not pleasing, we live like a family now. When anyone brings it home … it has to be shared among the households that don't have strength to cover such distances" (Female. Focus group one: Site 2, 2015).

> "Sometimes when I go out to collect firewood … when I have a lot of visitors … It's really difficult … difficult to get the quantity that will be enough to cook a meal that will accommodate everybody, so we have to go back again and again. This is tedious and we are suffering so much because of firewood collection but we don't have a choice" (Female. Focus group one: Site 3, 2015).

Other households had felt compelled by time poverty to start purchasing their firewood and complaints about the cost of firewood were common with one respondent stating that:

> "Firewood … in this community is our major problem, N100[7] worth of firewood won't be enough to prepare a meal for a family of three and firewood is almost going into extinction" (Male village elder. Interview one: Site 2, 2015).

4.4.3. Smoke-related concerns versus household budget constraints

Many respondents acknowledged how the discomfort of the smoke generated by three stone fireplaces and in some cases, concern about the health impacts of smoke had resulted in a desire to shift to a "cleaner" stove:

> "My wife … was experiencing pains in her eyes and when I took her to the hospital, I ended up spending so much money such that I have no savings again. Since then if she makes a demand in the kitchen, I quickly respond to it … unless I don't have [the means to do so]" (Male. Focus group two: Site 3, 2015).
> "When the smoke becomes so intense we make a demand that a stove be purchased. So women are the ones that make a demand that a stove be purchased" (Female. Focus group two: Site 2, 2015).

There was also some acknowledgement of the advantages of "cleaner" stoves in terms of cleaner homes or less drudgery associated with cleaning sooty pans:

> "Since I have been using the Abacha stove, my cooking pots have remained clean but the three-stone fire produces a lot of smoke and dirt … you don't experience that with Abacha stoves" (Female, Focus group one. Site 1, 2015).
> "Three stone fires and firewood smoke makes the kitchen look untidy including the cooking pots" (Female village elder. Interview two: Site 3, 2015).

7 £0.33 in February 2015.

Other respondents acknowledged the nuisance caused by smoke but said that they felt financially constrained from moving to higher tier cooking devices:

> "I am not comfortable cooking with firewood, and since I don't have money to buy kerosene I use firewood on my three-stone fire" (Female. Focus group one: Site 3, 2015).
> "Smoke … I am not comfortable with it … when I cook with firewood on my three-stone fire … it is difficult because of smoke … and I have to close the kitchen door and stay outside … periodically I go back inside the kitchen to tend the fires. It is not my desire to cook on a three-stone fire but in our community I have to cook in this way since I don't have alternatives" (Female. Focus group one: Site 2, 2015).
> "Despite our … awareness of different cooking technologies … we still use firewood because we have limited resources to purchase these technologies … We are aware of gas stoves for example but as I said earlier we are constrained by our low levels of income so the majority of people in this community cannot afford to redirect it to other non-profit yielding ventures" (Male village elder. Interview two: Site 2, 2015).

As the above quote suggests, despite the difficulties and costs associated with obtaining firewood and the smokiness of three stone fires, purchasing improved cookstoves was not regarded as a priority although some respondents suggested that they might be more popular in urban areas where the cost of fuelwood is higher. Even amongst a group of higher income households, however, improved cooking devices were placed below children's education, owning a business and owning property in a list of household priorities.

4.4.4. Socio-cultural factors influencing stove and fuel stacking

Further probing on this point coupled with direct observation revealed that most households owned more than one type of cooking device and the use of two devices at the same time was quite common depending on user priorities and the type or quantity of food being cooked. Echoing the literature on stove stacking (Masera et al. 2000, Ruiz-Mercado et al. 2011, Rehfuess et al. 2014, Ruiz-Mercado and Masera 2015), this allowed households flexibility to switch between cooking devices according to particular user preferences, changes in fuel availability or costs and household cooking requirements. Among households that owned a range of cooking devices, it was clear that reliability and

maintenance considerations were important influences on their willingness to purchase a new stove.

Some also raised concerns about the reliability of improved stoves and how easily they could be repaired if problems arose with them:

> "If we have good artisans that can repair the stove then we won't have any problems; otherwise it will be difficult to use and maintain the stove" (Female. Focus group two: Site 2, 2015).

As only site 1 had a stove repair workshop, however, a lack of access to stove repair artisans was identified as a barrier to the adoption of ICS that respondents were unfamiliar with or did not trust the quality and robustness of.

In contrast with the energy ladder model, households were found to shift down as well as up tiers in response to changing financial circumstances or fuel costs:

> "I cook mainly on my three-stone fire … though I have electric, kerosene and Abacha stoves but … [the] electric stove, has high electricity bills associated with it. I can't afford continuous usage and the price of kerosene too is high[8] but the Abacha stove is okay given my lean resources" (Female. Focus group one: Site 1, 2015).
>
> "I have a gas stove, though I stopped using it because of the refilling, transportation charges … all these have been … major problems and I now use my Abacha stove" (Female. Focus group two: Site 2, 2015).
>
> "I have a kerosene stove as well as my three-stone fire but I don't use it any longer since kerosene is very expensive. I now use my three-stone fire although the price of firewood is almost the same as kerosene" (Female. Focus group one: Site 2, 2015).
>
> "We cook mainly on the three-stone fire … though we have electric, kerosene and Abacha stoves, my daughters prefer the three-stone fire to these stoves" (Male. Focus group one: Site 1, 2015).

Other respondents described how they would choose their cooking devices according to the social situation they found themselves in:

> "I have a kerosene stove and my three-stone fire and I use them at the same time to prepare meals" (Male. Focus group two: Site 3, 2015).

8 Kerosene is sold at N115 in most gas stations in the study area.

> "I use my gas cooker when I have visitors because I normally want to stay around them so I cook inside the kitchen which is close to my sitting room but when I am with my family I cook their meals on an Abacha stove" (Female. Focus group one: Site 1 2015).
> "I have two stoves (kerosene and Abacha) in addition to my three-stone fire. If needed we would use all of them at the same time to cook the quantity of meal that would satisfy all visitors" (Male. Focus group two: Site 3, 2015).

In Tiv households where it is a cultural tradition for households to prepare large quantities of food as an indicator of socio-economic status, three stone fireplaces were particularly favoured as they allowed the cooking of large meals and/or catering for larger family sizes. Some participants reported that as a large household size is viewed as a blessing, they feel the need to prepare large quantities of food on a regular basis to satisfy the household as well as visitors. These results suggest families may outgrow their smaller improved cookstoves and revert to three stone fireplaces that can accommodate a larger pot:

> "I usually have a lot of visitors and people living with me so [an improved] stove may not be able to cook the desired quantity of food needed to entertain my guests" (Male. Interview one, Site 2, 2015).
> "I have stopped using my kerosene stove since my family size is now large and I have gone back to my traditional three-stone fire since it can cook the desired quantity of meals at once" (Female. Focus group one: Site 1, 2015).

Kerosene or Abacha stoves were also commonly used in these households to cook smaller or quicker meals with one respondent reporting the use of "the three-stone fire for preparing large quantities of food while the kerosene stove is for soup only" (Female. Focus group two: Site 1, 2015). Versatility and controllability were also noted as desirable stove characteristics.

> "I desire a stove that I will regulate the amount of heat to my cooking pot at the same time accommodate large pot sizes" (Female village elder. Interview one: Site 2).

Cultural preferences for the food cooked in particular ways were also mentioned as an influence on cooking system choice with respondents highlighting the benefits of smoke for food preservation and taste:

> "On the three-stone fire we use firewood as the main fuel for cooking and sometimes for preserving meat, which is one of the underlying traditional

> cooking practice. This is so because you cannot use another stove for meat preservation, so when it comes to that … firewood and the three-stone fire is utilized to give the meat an accentuated aroma that is highly appreciated. If I had a gas stove, I would still use firewood to preserve my meat because it is very important to the family" (Male. Interview one: Site 1 2015).

4.4.5. User preferences for rapid cooking

As illustrated in the quotes above, the combination of three stone fireplaces and firewood were also favoured on the basis of perceptions that they cook food quickly and save time. Typical responses from focus group participants included claims that firewood "cooks faster than any other fuel". Further discussions on this topic revealed that user perceptions about cooking speed were linked to flexibility in the amount of fuel that could be used on them. One respondent explained that:

> "With my three-stone fire I put in as much firewood as I can to enable my meals to cook faster" (Male. Focus group one: Site 1 2015).

Further discussions on this topic reflected a desire by male household members for their meals to be prepared quickly when they returned home. This encourages cooks to add more wood to their three-stone fires thereby increasing the heat and helping to perpetuate the belief that these traditional stoves cook faster than other devices.

4.4.6. Seasonal shifts in stove and fuel use

Nevertheless, the use of three-stone fireplaces tends to vary seasonally as they are often located outside the home and it is difficult to relocate them indoors during the rainy season. An additional problem is that households that collect firewood free of cost are forced to cook with wet wood at this time of year causing greater smoke emissions during cooking. Even firewood vendors struggle to keep their wood dry during the rainy season. Many villagers associated this with increased health problems and in addition to the male respondent who reported taking his wife to hospital with eye pain, a female respondent from site 3 recounted having spent a significant portion of her savings when her child was hospitalized in the 2014 rainy season as a result of smoke from wet firewood. During focus group discussions, the topic of increased smoke from cooking with wet firewood was a common theme with

some respondents noting a desire to purchase cleaner stove/fuel combinations:

> "During rainy seasons, women experience difficulties with smoke in their attempts to prepare meals as a result of wet firewood. This makes them demand improved cookstoves" (Male. Focus group one: Site 3, 2015).
> "In the rainy season, I use my kerosene stove because firewood is usually wet so it produces a lot of smoke. I don't use my three-stone fire during this time" (Female. Focus group one: Site 1, 2015).

As a result of these health-related issues, many households reported making a shift from their three-stone fireplaces to alternative fuel/stove combinations in the wet season.These examples highlight the drawbacks of tracking access to higher tier cooking systems use when information is only collected on the primary stove and fuel used as in these study villages, the answers may differ between the rainy and dry seasons.

4.5. Incorporating end-user preferences into stove interventions and SDG7 monitoring frameworks

Despite emphasis by the SDGs on promoting sustainability and inclusiveness, efforts to formulate global targets and tracking frameworks inevitably run the risk of making compromises in terms of their sensitivity to local context (Sesan 2014, Satterthwaite 2015). At the same time, top-down initiatives emphasizing the cost and time benefits of fuel efficient cookstoves or the health benefits of "clean" fuels and stoves have had limited success in promoting their widespread uptake and sustained use by users of traditional biomass stoves (Sesan 2014, Thurber et al. 2014). Even though access to finance can be an important enabling factor within the ICS sector (GIZ 2013), contemporary market-driven approaches have often failed to meet the needs and priorities of lower income groups that have low demand for ICS (Kshirsagar and Kalamkar 2014). As a result, the cost of purchasing an ICS - especially one that requires regular fuel purchases - may prove too high for many potential users.

As data from Benue state illustrates, this is especially true when households face a range of competing financial priorities (food, education, healthcare, transport) and may still obtain some of their biomass fuel free of cost. Also, as the Benue respondents and Nottingham bake-off cooks illustrate, end-user cooking preferences and priorities are spatially and culturally specific

and often differ widely from more technology-oriented systems for classifying improved cooking systems (Troncoso et al. 2007, Sesan 2014, Ray et al. 2014). Indeed, some respondents reported abandoning technologically improved systems in favour of lower rung/tier systems (or poorly maintained higher rung/tier systems) that better met their needs. Echoing research by Masera et al. (2000), many respondents from Benue and the bake/cook-off events practiced stove and fuel "stacking" in response to fuel and stove access/costs, the technical characteristics of different cookstoves (e.g. the type of food being cooked, the size of pot they could accommodate, their cooking speed and the amount of smoke created) and broader cultural preferences for particular stove types.

Such trends indicate the need for cookstove initiatives to make greater use of more participatory approaches that seek to understand end-user priorities for different technologies and the factors that help to create demand for these in different socio-economic, socio-cultural and geographical contexts. In particular, greater emphasis on "software" (as opposed to hardware or technology-oriented) approaches and social marketing initiatives of the type successfully used in the sanitation sector has potential to better understand and target the priorities of different user groups. Indeed, discussions about how to adapt such approaches that took place at a workshop organized by GACC, USAID, Universidad Peruana Cayetano Heredia and the Swiss Tropical and Public Health Institute in 2015 (GACC et al. 2015a) indicate increasing interaction between the water, sanitation and hygiene (WASH) and energy sectors.

In part, this reflects acknowledgement that increasing demand for cleaner fuels and improved stoves among low-income biomass-dependent groups is likely to be particularly challenging; especially where biomass fuel can be gathered free of cost and national energy policies overlook its importance as a household energy source (Pachauri and Jiang 2008, Barnes et al. 2011, Ray et al. 2017). But despite the recognition that - like poor sanitation - HAP-related problems are unlikely to be ameliorated without a community-wide response, the scope to transfer the types of community-led participatory initiatives used successfully in the sanitation sector are seen as limited (GACC et al. 2015b). This is because it is assumed that participatory approaches used in CLTS will be difficult to replicate in the energy sector given that cooking with "dirty" fuel lacks the sense of disgust widely associated with poor sanitation. Another hindrance to non-solid fuel adoption is that knowledge of HAP-related health problems is often low among low-income groups with low

levels of education. In Nigeria, this reflects the lack of health education programmes focused on HAP compared to those promoting improved sanitation or malaria prevention (Akintan 2014) coupled with low levels of female integration (as change agents or ICS entrepreneurs) within the ICS value chain (Sesan et al. 2019). Other barriers include the wider benefits associated with smoke amongst communities that - in the absence of other methods of food preservation - rely on it for curing fish or meat (Akintan 2014).

Nevertheless, as the bake/cook-off events and Benue fieldwork have shown, participatory approaches can be designed to promote knowledge-sharing about both end-user priorities and the technical characteristics of ICS. They can also be used to encourage analyses of the wider impacts of biomass fuel use with efforts made to encourage discussions of the time, missed work/education opportunities and danger (e.g. risk of attack from animals or humans) associated with gathering this and the groups most affected by this. Resource mapping or matrix ranking exercises are useful for highlighting wider environmental or cultural factors underlying availability of and preferences for different cooking fuels or stoves whilst providing insights on locally specific barriers or enablers for the adoption of different fuels or technologies. Likewise, wealth ranking exercises can be useful for identifying key indicators of social status that help to contextualize energy choices in relation to other household priorities, aspirations and cultural norms regarding cooking system use. Approaches focused more directly on enhancing community-level understandings of HAP-related health issues, meanwhile could help communities to make links with commonly experienced symptoms. Drawing more directly on the triggering elements of CLTS, it may even be possible to mobilize dissatisfaction and drudgery associated with cleaning sooty cooking pots and living spaces to enhance awareness of HAP-related respiratory problems and their community-level impacts.

With regard to the future monitoring of which areas and groups make primary use of clean fuels and cooking technologies, the ambitious targets associated with SDG7 clearly require multi-faceted tracking frameworks that allow disaggregated data to be collected. GTF data collection activities will therefore have to go well beyond the scope of existing DHS questionnaires which only ask about the type of fuel households mainly use for cooking and whether cooking takes place in the house, outdoors or in a separate building. To provide useful insights on the extent to which economic factors hinder a shift to non-solid fuel, data need to be collected on the cost, availability and quantity of different fuels used. As case studies from Benue and elsewhere

illustrate (Ruiz-Mercato et al. 2011, Ruiz-Mercato and Masera 2015), data on primary fuel and cookstove use provide only a partial picture. Widespread stove and fuel stacking along with seasonal or price-related shifts in stove/fuel use (both up and down tiers/rungs) can have important implications for exposure to health issues connected to HAP; the assessment of which need more detailed information on stove use as well as the health benefits associated with improved biomass stoves, noting that a recent randomized controlled trial (Mortimer et al. 2016) found no evidence that an intervention comprising cleaner burning biomass-fuelled cookstoves reduced the risk of pneumonia in young children in rural Malawi.

In recognition of this and despite SDG 7.1.2's emphasis on primary fuels and cooking technologies, recent workshops designed to feed in to the development of monitoring approaches for SDG7 highlight the need to capture information on multiple stove use and variations in stove or fuel use by season (Ruiz-Mercado 2015). Although the GTF does seek to capture information on "convenience" attributes associated with acquiring fuel and time taken to prepare stoves for cooking, priorities identified by our bake/cook-off cooks and Benue respondents for controllable, adaptable and quick-cooking stoves that can cater for large family sizes are not monitored, despite their likely influence on fuel and cookstove choices (Concern Universal 2016, Loo et al. 2016). Attributes linked to stove affordability, meanwhile, are only monitored for stove tiers 4 and 5, despite their importance in hindering a shift from three stone fireplaces. Likewise, safety-related and indoor air quality attributes depend on the availability of ISO data emissions data which is mostly restricted to commercially-available stoves that are beyond the price range of many low-income biomass users. As a result, questions need to be asked about who benefits from testing and certification (Mukulu 2014, Karve 2014) as it is likely to increase the cost to end-users whilst decreasing the margins of small-scale producers that may be better able to adapt their stoves to end-user requirements.

In pursuing their respective efforts to promote the adoption of clean cookstoves and fuels in 100 million households and "a data revolution for the energy sector" (IEA and World Bank 2015: 30), GACC and the GTF therefore need to focus attention on understanding and seeking to address key barriers faced by the biomass dependent poor. At the same time, national governments need to pay greater attention to the importance of biomass for household energy needs whilst creating enabling environments for ICS and clean fuel uptake. The slow uptake of non-solid cooking fuel to date suggests that SDG7's goal

to "ensure access to affordable, reliable, sustainable and modern energy for all" by 2030 urgently needs more effective user-focused approaches that seek to understand the spatially specific and culturally-rooted nature of cooking practices whilst seeking to facilitate locally acceptable and appropriate forms of behavioural change. Solutions are starting to be sought from successful approaches within the WASH sector (Graham, 2015; Rosenbaum, 2015) but adaptations of CLTS-style community-led participatory approaches that play on distaste for the dirt associated with non-"clean" biomass fuels could help to promote change at the scale needed for a significant shift to the adoption of modern cooking solution to occur.

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