THE POTENTIAL AND PROSPECTS OF IMPROVED COOKSTOVES (ICS) IN ZIMBABWE

Tafadzwa Makonese[1, 2], Godfrey Chikowore[1, 3] and Harold J. Annegarn[1, 2]

[1] University of Johannesburg, Dept. of Geography, Environmental Management & Energy Studies, PO Box 524, Auckland Park 2006, Johannesburg, South Africa

[2] SeTAR Centre, University of Johannesburg, Auckland Park Bunting Campus

[3] University of Zimbabwe, Institute of Developmental Studies, Mount Pleasant, Harare, Zimbabwe.

ABSTRACT

In Zimbabwe, alternatives to grid electricity are being sought in the light of limited electricity supply and under-performance of major electricity generation plants following the economic meltdown affecting the country since the mid-1990s, triggered by the Economic Structural Adjustment Programme (ESAP), and more recently due to political instability. Extensive black-outs routinely up to 12 hours per day and even for several days are common in some areas. Consequently, the majority of households continue to rely substantially on wood fuel to meet their basic daily energy needs. Yet the provision of modern energy services and technologies to these households does not seem to be a priority for national energy policy makers. Although improved cookstoves (ICS) are in greater use in rural areas than urban settlements of Zimbabwe, their potential remains largely unexploited. This research aims to highlight the marked potential and current prospects of improved cookstoves in rural and urban communities of Zimbabwe. Ultimately, this research will better inform policy makers, government, academia and the public about cookstove technologies with reduced fuel use, reduced energy costs, and user friendly capacity to improve health in rural and urban communities.

***Keywords*: Improved cookstoves, national energy policies, households, health.**

1. INTRODUCTION

Zimbabwe is a developing country which is currently in the grips of an economic and political crisis [1]. This has negatively affected the power sector in terms of growth and investments especially in rural and urban communities of Zimbabwe. The power sector has been starved of investments and on a long term this resulted in an inadequate revenue flow into the country to finance new investment in the 2000 decade. The government and the utility, Zimbabwe Electricity Supply Authority (ZESA) have recognised their inability to meet these challenges and have initiated a reform program in order to open up the power sector to private investors [1]. As a result alternatives to grid electricity are being sought due to limited electricity supply and under-performance of major electricity generation plants. This unfavourable energy supply scenario was an outcome following the economic meltdown which gripped the country since the mid-1990s due to the adoption of the prohibitive Economic Structural Adjustment Programme (ESAP), and more recently to political instability and impact of the 2001 Zimbabwe Democracy and Economic Recovery Act (ZDERA).

Fuelwood is the most important form of domestic fuel in the rural and urban areas of Zimbabwe. It is the major source of energy for cooking, lighting and space heating for the majority of the populace, regardless of social or economic standing. This condition is made possible by the fact that fuelwood is either collected for free from nearby wild forests and random urban street prunings. Larger stocks of fuelwood are also bought from rural/urban bound small and medium scale street vendors. There appears to be a correlation between lack of modern energy sources and the continued use of fuelwood in sub-Saharan Africa and Zimbabwe in particular. In Zimbabwe, extensive black-outs, frequently for durations of up to 12 hours per day, and even for several days in some areas compel people to resort to fuelwood to meet part or all of their daily energy needs. Above all, these electrical power shortages are a reflection of the government’s failure to invest in electricity and renewable energy technologies. In addition, governments are considerably divorced from the regional, continental and global energy development programs which they could conveniently and systematically exploit to the most possible limits.

Within the scientific community and amongst governmental and international agencies, there is growing concern about the adverse impacts placed on the environment consequent to the use of biomass (especially fuelwood) in developing countries [2]. Some of the commonly cited problems include indoor air pollution, atmospheric pollution and ill-health of female and children who tend to spend most of their time around fuelwood fires [3,4]. When used sustainably fuelwood is a cheap and renewable energy source especially suitable for developing country situations [2]. The problem, however, is the air-polluting effects associated with its use.

Links between energy and the Millennium Development Goals (MDGs) and the existence of widespread poverty in Zimbabwe makes it important to address the challenges and prospects for energy service provision in the country [5].

However, the provision of modern energy services and technologies to these households does not seem to be a priority for national energy policy makers. Although improved cookstoves (ICS) are already in use in some parts of the country, their potential remains largely unexploited.

The aim of this research is to highlight the potential and prospects of utilisation for improved cookstoves in urban and rural areas of Zimbabwe in the new millennium. The study analyses and assesses barriers in the adoption of improved cookstoves among the urban and rural poor households, drawing on policy documents, statistical data from the Zimbabwe Central Statistics Office (CSO), records of donor-funded stove intervention programmes, and published primary and secondary sources. Recommendations are drawn on options for improving provision of essential energy services to the urban and rural poor; and how the government could assist in the dissemination and adoption of improved cookstoves. In addition to these recommendations, the study will have both a theoretical and practical relevance to stove programme managers and energy policy makers in guiding improvements in existing stoves; the development of new designs; and the effective dissemination and adoption of these devices. Ultimately, this research will contribute to reduced fuel use, reduced energy costs, and to improved health in rural and urban communities where improved cookstoves are in wider use.

2. ENERGY POLICY IN ZIMBABWE

There is growing consensus among policy makers that efforts to disseminate renewable energy technologies, especially improved cookstoves, in Africa and notably in Zimbabwe, have fallen short of expectations [6]. Plans to have a policy on access to household energy are in place but officials are still working on the policy at the ministerial level. Once adopted, the proposed policy would ensure the increased availability of affordable modern energy and renewable energy technologies to the poor while at the same time protecting the environment [7].

The Zimbabwe Draft Energy Policy (ZNDEP) has five main objectives: ensuring accelerated economic development; ensuring accessibility, availability and reliability of electricity supply to the populace and facilitation of rural development; promotion of small-medium scale enterprises; ensuring environmentally friendly energy development; and efficient utilisation of energy resources. The policy seeks to promote the use of low cost, affordable alternative energy sources, sustainable energy use and increased public private partnerships [7].

3. IMPROVED COOKSTOVES IN ZIMBABWE: PROSPECTS AND POTENTIAL

Given the relatively low dissemination of improved cookstoves in developing countries and the projected increase in the number of people relying on fuelwood, the potential for improved cookstoves is vast [8]. Improved cookstoves are currently being used in all parts of the world to address issues of health and ease of pressure on forest resources due to the excessive harvesting of fuelwood. This process has been worsened by other anthropogenic activities related to reclamation of land for agricultural purposes, settlement and mining, construction of industries and road networks. It is in this context of perception that a variety of improved cookstoves have been designed and developed which include fixed and portable types namely: metal and clay; single pot and multiple pot, with chimney and without chimney designs. These are primarily designed to reduce cooking fuel consumption, reduce smoke emission, cleaner utensils, and savings in time required for cooking [9].

In Zimbabwe, improved cookstoves have been constructed for rural domestic kitchens with the primary objective of increasing energy efficiency. Most of the stove projects have embarked on a strategy which assumes that traditional stoves and fireplaces commonly used in the country have low cooking efficiencies and are a risk to women's health because of the smoke they emit in the kitchen. However, in spite of these technological inadequacies in traditional stoves, improved cookstove technology has not yet made the desired impact in the country. A variety of reasons may be attributed to these set backs.

The general pattern in Zimbabwe is that with increasing income people generally move up the *energy ladder* from firewood to charcoal or kerosene and then to liquefied petroleum gas (LPG), natural gas, or electricity for cooking and space heating needs [10]. Modern technologies such as pelletized wood and improved coal stoves may revise this concept of energy switching. The underlying factor impeding the movement toward more modern fuels, in both rural and urban communities of Zimbabwe is declining real incomes and considerably high levels of unemployment. In many parts of Zimbabwe, the increase in national income has barely or not kept pace with population growth and rise in inflation over the 1990 decade. As a result some households have had to switch back from modern fuels to traditional biomass burning stoves and fuels. In addition, poor distribution systems for modern fuels, especially in smaller cities and towns and the recurrent power outages, have prevented many families from switching to modern fuels. This means that the general populace will continue to rely on fuelwood as their main source of energy for basic needs of cooking and space heating, let alone baking farm bricks at the brick yards that have sprouted in rural and urban settlements.

Because poor people often cannot afford or obtain modern stoves and fuels, the development of more efficient, energy saving, and inexpensive improved cookstoves can considerably alleviate local pressure on wood resources. The majority of households in Zimbabwe still use the 3-stone fire for cooking and heating. This method of cooking delivers 5-10% of useful energy output, indicating that vast amount of bio-fuels are being burned at unsustainable rates for little gain. Improved cookstoves could help shorten the walking time required to collect fuel, reduce cash outlays necessary for purchased fuelwood and reduce the pollution released into the environment [10]. Yet although the potential benefits of modern, efficient biomass stoves have been obvious since the first discussions of the *fuelwood crisis* [11] and many programmes have been undertaken to make improved biomass stoves available to potential users, the stoves have been disseminated far less widely than expected. All these developments indicate that the technologies availed are either too expensive for the majority of the rural population or they depart from the cultural perceptions of what the community deem an ideal cooking stove technology for them, by cultural standards.

In Zimbabwe, a few improved stove programmes have been a success. This includes the *Tsotso* stove project introduced in the country in the 80s. The stove was originally developed by David Hancock at the Development Technology Centre based at the University of Zimbabwe. Among the desirable features of the stove were fast cooking, less smoke, and fuel economy. However, it has been criticised for damaging metal pots at the centre [12,13]. Other stove projects such as the *Chingwa* met with limited success. This stove was widely disseminated by the government through the Department of Energy and NGO,s such as the Zimbabwe Women's Bureau [12,13]. The *Yugen* mud stove was introduced in the Plumtree district by AVOCA training centre. The stove was constructed outside the kitchen. It was difficult to build thus requiring experienced artisans. Because it was situated outside, the ash hole became a habitat of insects and snakes. Importantly, the stove was a failure because many households could not afford the wire mesh used to reinforce the mud [12]. In a survey conducted by SCEE [13] it was established that most of these stoves are no longer in use and people have resorted back to open fires [13]. Most of stove programmes in Zimbabwe collapsed soon after donor funding termination. Causes for collapse have been attributed to poor implementation strategies, inappropriate technologies, lack of community participation and training [6].

There have been many disappointments with regards to improved cookstoves world over, leading some donor organisations to focus on other ways of alleviating the fuelwood crisis. Currently focus by some non-governmental organisations (NGO's), such as Environmental Solutions Africa, is on the supply strategy of planting a million trees in each district of Zimbabwe. However, this project can be successful and more meaningful if coupled with a demand-side approach of introducing improved cookstoves projects, with a strong cultural bias. If energy efficient improved cookstoves are adopted on a larger scale, they would reduce the pressure on biomass resources. The use of more efficient stoves to reduce demand for wood to sustainable levels is usually more economically viable than planting new trees, at least initially [10].

The discouraging experience with improved cookstove promotion stems from a variety of factors discussed in the section below.

4. CHALLENGES FACING WIDE-SPREAD DISSEMINANTION AND ADOPTION OF ICS IN ZIMBABWE

The rate of diffusion of energy-efficient technologies has been widely studied in the international literature. The following are problem areas that require immediate attention if improved cookstoves are to realise their substantial potential in Zimbabwe:

4.1 INSTITUTIONAL BARRIERS

A key factor influencing the implementation and promotion of improved cookstoves in the country is the existing institutional infrastructure. A strategically set up and conducive institutional framework has in most cases proved to be one of the prerequisites for successful technology dissemination. However, the Department of Energy (DoE) is not represented at provincial or district level, hence local planning has limited input from the department in terms of energy development [13]. Consequently there is need to increase the Department of Energy representation at local levels to ensure that viable contributions are effected.

Among the problems which plague the institutions that support research and implementation of small-scale and decentralised energy technologies and management methods is lack of steady funding [14]. Equally critical, however, are the paucity of training venues, technology and information exchange, and technology standards for these often overlooked energy systems [15,16]. Consistent scholarly research and attention to problems of small-scale and decentralised energy technology and expertise dissemination is absent in Zimbabwe.

From an institutional point of view, the programmes that have had the greatest success are those in which the government was not involved in the production or sale of the improved stove [10]. Central planning and reliance on numerous layers of bureaucracy have hindered many programs in the developing world [10,17].

4.2 ECONOMIC AND FINANCIAL BARRIERS

One major obstacle to rapid improved cookstove diffusion is stove price. Improved cookstoves are typically about twice or more expensive than local traditional stoves. Although in the long run improved stoves save money, the initial cash outlay required may prevent poorer people from affording the stove [10]. It is now clear and evident from the Zimbabwean situation that not only poor people are using wood. In light of this, it is imperative to sell well fabricated good quality wood-burning stoves which are as durable as the traditional stoves with replacement parts (such as grates) readily available and inexpensive. These measures have the potential to transform the improved stove market. With a 'modern' improved cookstove there is no need to move up the energy ladder if the cooking experience is 'modern' and the fuel is local. However, governments and donors could still assist by subsidising stoves for poor families even though subsidising stoves is risky as a promotion strategy. High fuel prices or scarce supplies of fuel increase the likelihood of stove adoption.

In Zimbabwe small scale investors in the energy sector have difficulties accessing loans from the bank. The Africa Development Bank (ADB) has a facility through the Zimbabwe Development Bank (ZDB) where the interest rates are as low as 5%. However, the on-lending rates of the ZDB are prohibitively high ranging between 30% and 50% due to exchange loss cover. Such high rates make the funding inaccessible to artisans [13]. The government has started providing micro-credits to consumers through revolving funds and if exploited fully, this process will go a long way in ensuring the adoption and dissemination of improved cookstoves. However, micro-financing has not been successful in promoting improved cookstove projects. The main barrier to micro-finance is that the improved cookstove projects were directed to the rural poor who do not have knowledge of such financing methods and can not afford repayments due to high interest costs [13].

The ESMAP programme in Africa, sponsored by UNDP, World Bank and other donors exemplifies the use of financial incentives to promote renewable energy and improved cookstoves.

4.3 PRICING DISTORTIONS

As the cost of the technology falls, more consumers receive positive net benefits and adopt the technology [18]. If benefits are normally distributed across consumers, the rate of adoption will follow an S-shaped curve [19]. This suggests that higher energy prices or lower capital costs should increase the rate of technology adoption. Empirical evidence from the United States suggests that higher energy prices have encouraged the adoption of energy-efficient room air-conditioners, central air-conditioners, and gas water heaters [20]. There is, however, evidence that decreases in capital costs have had a larger effect on adoption of improved cookstoves than corresponding increases in operating costs [21,22]. This suggests that either myopia (For instance, high discount rates) or capital market constraints have played a role in technology adoption by consumers.

4.4 POLICY BARRIERS

Failures of improved cookstove programmes emanated from the deficiencies in policy perspective and promotion of poorly designed cookstoves. The adoption of renewable energy technologies and more specifically improved cookstoves is affected by targeted and general government policies that distort prices. Of particular relevance is the economic structural adjustment programme (ESAP) that Zimbabwe began late in the 1990 decade. ESAP was initially planned to last until 1995 [23]. Although the programme was not the result of an agreement between the World Bank and Zimbabwe, it contained most of the ingredients of World Bank structural adjustment programmes (SAPs) seen elsewhere in Africa. These elements included trade liberalisation, budget deficit reduction, deregulation of prices, wages, transport and investment, and commercialisation and improved efficiency of parastatals [24,25]. However, there were repeated failures to meet the targets for the budget deficit. Together with a combination of policy mistakes and external shocks, the accumulation of public debt that resulted from the budget deficit set off the ongoing economic crisis in the late 1990s, and consequent political tensions [23,26].

The impact of ESAP on the energy sector in Zimbabwe has been to phase out subsidies on all liquid fuels except paraffin [23]. ESAP has had negative impacts on low-income urban households, entailing falling buying power and reduced social services. Since its adoption, there has not been a simple energy transition but a growing dichotomy between wealthier households who are able to adopt modern fuels (including backup diesel powered electricity generators), and poorer households who are increasingly forced to choose biomass alternatives. Thus the adjustment in turn had negative impacts on woody plant resources [27] and the adoption of related improved cookstoves. Economic sanctions on the country due to the on-going political crisis have exacerbated the energy poverty experienced by deep rural and low income urban households. This in turn has had adverse effects on the adoption of renewable energy technologies and improved cookstoves due to lack of buying power by the general populace.

Several governments provide capital subsidies for installation of renewable energy systems. However, capital subsidies need to have a defined phase out time frame to ensure efficiency improvements in improved cookstoves. Subsidies often result in the distortion of market prices of improved cookstoves. It should be recognised that taxes or subsidies to fuels that compete with biomass fuels also may have a significant impact on the success of stove programmes [10]. Generally people tend not to value things that are given to them for free compared to a situation where they would have invested money in the gadgets. Incentive-based renewable energy programmes are in operation in several developing countries. A principal role of governments and donor agencies in successful programs could be in technical support and assistance in determining where demand is strongest.

Governments and donors can assist in formulating a policy framework that provides incentives to private sector operators to engage in the production, distribution, and sale of improved stoves. The elements of such a policy framework would include criteria for approving stove projects, credit facilities for stove makers, facilitation of availability of raw materials, and promotional support [10]. For example, in Rwanda, the government provides promotional support to stove programmes and is preparing a household energy sector policy that will include quality criteria for stoves that may be sold [28]. Perhaps the most important role for governments and donors is in institution building and training. The most important objective of outside assistance should be in creating the institutions and training the people necessary to sustain the stove promotion efforts.

Other measures include promotion of energy service companies (ESCOs) that address several barriers such as lack of up-front financing, credit facilities, and technical knowledge. Perhaps the most important involvement is by non governmental organisations (NGOs). NGOs are not dominated by large bureaucracies, are quick to react to problems, are committed to energy conservation, and are sympathetic to the main woodstove users, including rural women and the urban poor and middle class. However, in Zimbabwe most NGOs have been banned from participating in these and other projects due to the political scenario in the country. NGOs are accused by the existing government of undermining the democracy and sovereignty of the country by supporting projects initiated by opposition parties.

4.5 SOCIAL BARRIERS

As the majority of potential cookstove users are fuel gatherers, most of the benefits from the use of the improved cookstove are likely to be non-monetary. Most renewable energy projects implemented in Zimbabwe have been based on the assumption that rural communities need alternative energy to replace fuelwood. This has result in a slow adoption of improved cookstoves in these social settings. Where fuelwood is non-commercial, stove diffusion will be much slower because users have to be led gradually into perceiving the net benefits of improved cookstoves.

Many poor people in villages are not capable of paying for minor maintenance costs, such as replacement of grate and chimney [9]. Many times, the improved cookstoves are poorly fabricated and are found to be incompatible with traditional ways of cooking. For example, any change required in the posture of the cook while cooking may not be accepted in some cultures. For example, in the rural communities in Zimbabwe it is a taboo for women to cook while standing. Improved cookstoves do not usually satisfy the other perceived culturally biased needs of the users such as lighting, space heating, repelling insects and pests, drying of thatched roof, and providing a communal gathering point [29].

Cooking speed in Zimbabwe is regarded as important by stove users. In a study carried out by Gill [30] in villages in Zimbabwe it was noted that users are more concerned about cooking a meal quickly than about fuel efficiency since the fuel is gathered free of charge. This means that the traditional stoves used should cater for multiple pots and a variety of pot sizes. Modifications have been made to the 3-stone fire by introducing a four-legged metal grate with three to four pot rests of different sizes. This allows the cook to prepare the relish (normally prepared in a small pot) and the staple meal (prepared in a large pot) concurrently saving her time to do other household chores. Most of the improved cookstoves being disseminated in the developing world are single pot stoves with a specification for the pot size to maximise its efficiency. However, a cook may take up to twice the amount of time to prepare a meal using the improved stove than when using the traditional fires. This is undesirable if there is need to prepare a quick meal for important visitors such as in-laws, village heads and chiefs.

People in the rural areas and villages have been socialised into believing that electricity is the only energy source that indicates improvements in livelihood, social development and status. The government on the other hand, through its political wing, has been advocating for electrification of rural communities. For example, ZESA introduced the Rural Electrification Agency (REA) during the turn of the century with the mandate of electrifying rural communities. This programme has suffered a major set back due to government's failure to invest in electricity and renewable energy technologies. Thus the introduction of improved cookstoves to some sections of the rural communities may be seen as government's failure to deliver electricity to the villages as promised. This indirectly affects the uptake of improved cooking devices. There is, therefore, need for government through its various departments to educate rural communities on the importance of alternative energy technologies in the fight against poverty and environmental degradation.

Traditional stoves and fire-places in the developing world are versatile as they are able to burn a variety of fuels and serve a number of practical and socio-cultural functions [30]. Improved cookstove rejection occurs when one or more of these needs are not met by the devices but are valued more than the promised fuel and time savings; this is most evident in areas where fuelwood is non-commercial [29]. In Zimbabwe the 3-stone fire can be used to balance a 200L drum during beer brewing and the fuel remaining after cooking can be used for space heating in winter and the roasting of mealies and tubers in the harvest season. Currently in major cities and towns, due to the recurrent black outs, the 3-stone fire is used to provide lighting at night during meal times. In low-income urban communities which can not afford to buy candles intermittently, rely on the 3-stone fire to provide lighting during meal times and only use candles sparingly to put away used dishes and make their way to bed.

4.6 TECHNICAL BARRIERS

The most important reason seems to be the fact that many of the improved cookstove designs do not fulfil their claim to save substantial amounts of fuel. Properly designed and expertly operated cookstoves are undoubtedly more efficient than the traditional ones under laboratory conditions, but their fuel savings, under field conditions, are debatable [31,32,33]. This uncertainty in performance of improved cookstoves, especially when tested using protocols designed to make that particular stove appear to be highly efficient, prevents accurate programme and policy formulation. Inconsistencies result from lack of strictly uniform fabrication techniques of the devices; every other stove is a unique product rather than a standardised item with a common set of efficiency measurements.

Lessons can be drawn from the Lorena stove programme in Sri Lanka. The low efficiency of some stoves compared to the traditional stoves can be attributed to poor or inaccurate designs [30] and lack of robust and standardised stove testing methods. ICS have been evaluated using different testing methods limiting inter-comparability of different studies. There is an agreement that precise testing conditions and procedures, if clearly spelled out, will make it possible to correct for methodological differences, making the results more comparable [34].

The improved stoves may allow use of only certain sizes of fuel wood pieces, thus further constraining the choice of fuels. Stove designers, in their desire to reduce heat loss, provide a small fuel chamber for adding fuel, requiring the cook to spend much time in cutting the wood into small bits that fit in the chamber [10]. This has been a technical challenge in the adoption of the StoveTech® Green fire stove in Zimbabwe. Furthermore, the installation and repair of improved biomass cookstoves require skilled labour, whereas traditional cookstoves can be easily installed and maintained by the user [13, 35].

Good engineering principles must be matched by effective involvement of local artisans and users if efficient stoves are to be put into widespread use [10]. The stove maker should be involved in the design because efficiency and construction standards conceived in the laboratory may make the stove too complicated to produce profitably. Stoves that are mass produced by a group of artisans or a small factory will be disseminated far more quickly than custom-built models whose construction and installation may depend on the availability of trained technicians or installers. The different styles of cooking in various countries dictate different stove designs. Thus it is a good idea to introduce an improved stove design into a selected set of households on a trial basis early in the programme. However, there is nothing to offer people who would lead the industry, creating demand for value-added biomass fuels that would stimulate an entire new and locally based 'silva-culture' industry.

4.7 INFORMATION BARRIERS

An alternative theory of technology diffusion postulate that the limiting factor in technology diffusion is information, and that the most important source of information is people who have already adopted the technology [18]. This implies that adoption itself generates information externalities. These externalities and the fact that information is a public good provide a rationale for government provision of information about energy efficiency and related devices.

Related to lack of information are agency problems and lack of knowledge of the life-cycle benefits of energy-efficient technologies [18]. Several countries have initiated informative programmes to promote renewable energy technologies and improved cookstoves. The stakeholders can be educated and supplied with the necessary tools to evaluate the devices and design implementation. International donors can serve an important role in facilitating information exchange on the technical and managerial aspects of stove programmes. Every donor-assisted programme thus should have funding available and staff designated for collecting information in a timely and accessible manner.

5. RECOMMENDATIONS AND RESEARCH NEEDS

There is a large international literature that examines factors affecting the rate of diffusion of improved cookstoves and related technologies [18,36,37]. However, there are virtually no such studies for Zimbabwe. Such studies would provide useful information about the impact of changes in energy prices, changes in capital costs, energy efficiency standards, or technology adoption subsidies. All of these changes in energy markets and policies will continue to have an important influence on energy costs in Zimbabwe and the country's CO_2 emissions.

We propose further research in social marketing of cookstoves in Zimbabwe. Social marketing focuses on effecting behavioural change in the community [38]. Social marketing factors affecting the target market such as cooking comfort, convenience, and safety in the use stoves are starting to receive attention [39]. Mare and Annegarn [38] identifies the lack of existing stove markets, lack of attention to consumer needs and a lack of attention to commercial approaches as causes of failure of stove projects. .

Specialised agencies to plan and promote improved cookstoves should be created in Zimbabwe. Regulatory agencies can also be set up in response to the need for liberalisation of the energy sector. More importantly, monitoring should be used as a key tool in stove project management. Surveys and needs assessment studies are carried out earlier and fed into monitoring by providing baseline information and identifying items which are of strategic importance to the project. Feasibility studies can then define the conditions under which the project is feasible, thus identifying key points to be monitored [30]. In principle monitoring of improved cookstove programmes can involve the following:

- Determination of the number of devices built and disseminated
- Determination of the number of devices still operational in the field
- Measurement of the operational performance in the field
- Obtaining user feedback; and

- Measurement of the implications or effect of the adoption of the devices with respect to the overall goal of the project.

It should be emphasised, however, that even when the overall savings in fuel are small, there can be a significant improvement in welfare because people are more productive with the same amount of fuel. Thus, in designing monitoring and evaluation systems for improved stove programmes, it may not be enough to look at fuel savings alone.

These research needs should help policymakers understand behaviour of consumers and firms in the adoption of energy-efficient technologies and thus inform government policy in this area.

6. ACKNOWLEGMENTS

We would like to acknowledge input by Environmental Solutions Africa, Zimbabwe and all staff at the SeTAR Centre, University of Johannesburg. GC is a Senior Post-doctoral Research Fellow at UJ, on sabbatical leave from the Institute of Developmental Studies, University of Zimbabwe. This study was funded in part by an NRF Focus Area bursary to TM, and by a University of Johannesburg Quick Wins Grant for the EnerKey Sustainable Megacities programme.

7. REFERENCES

[1] Kayo, D.: "Power sector reforms in Zimbabwe: will reforms increase electrification and strengthen local participation" *Energy Policy*, Vol. 30, 2002, pp. 959-965.

[2] Marufu, L., Ludwig, J., Andraea, M.O., Meixner, F.X. and Helas, G.: "Domestic biomass burning in rural and urban Zimbabwe- Part A" *Biomass and Bioenergy*, Vol. 12, No. 1, 1997, pp. 53-68.

[3] Barnes, D.F.: *Clean Household and Indoor Air Pollution*, IES, World Bank, 2006.

[4] Taylor, P.R.: *The Uses of Laboratory Testing of Biomass Cook-stoves and the Shortcomings of the Dominant U.S. Protocol*, MSc Thesis, Iowa State University, Ames, Iowa, 2009.

[5] Karekezi, S. and Majoro, L.: "Improving energy services for Africa's urban poor" *Energy Policy*, Vol. 30, 2002, pp. 1015-1028.

[6] ProBEC: *Special focus on Zimbabwe*, ProBEC Newsletter, February 2001. http://www.bioenergylists.org/stovesdoc/GTZ/ProBEC_newsletter_Feb_2001.pdf

[7] Department of Energy and Power Development (2009). http://www.energy.gov.zw/index.

[8] Karekezi, S., Lata, K. and Coelho, S.T.: *Traditional biomass energy: Improving its use and moving to modern energy use*, AFREPEN Report No. 308, AFREPEN/FWD and Sida/SAREC, Sweden, 2004.

[9] Quadir, S.A., Mathur, S.S. and Kandpal, T.C.: "Barriers to dissemination of renewable energy technologies for cooking" *Energy Convers. Mgmt.* Vol. 12, No. 12, 1995, pp. 53-68.

[10] Barnes, F.B., Openshaw, K., Smith, K.R. and van der Plas, R.: *What makes people cook with improved biomass stoves? A comparative international review of stove programs*, World Bank Technical Paper Number 242, Energy Series, Washington, D.C, 1994.

[11] Munslow, B., Katerere, Y., Ferf, A. and O'keefe, P.: *The fuelwood trap: A study of the SADCC region*, Earthscan Publishers, 1988. ISBN: 9781853830075.

[12] Mika, L. and Tahwa, J.: *Wood burning stoves of Zimbabwe*, ProBEC Special Focus on Zimbabwe Newsletter, February 2001.

[13] SCEE.: *Implementation of renewable energy technologies-Opportunities and barriers: Zimbabwe country study*, UNEP, Denmark, 2001.

[14] Kammen, D.M.: *Technological innovations and diffusion in developing countries*, Annual meeting of the international energy workshop, EMF/IEA/IIASA, Stanford University, USA, 18-20 June 2002.

[15] Kozloff, K. L.: "Rethinking development assistance for renewable electricity sources" *Environment*, Vol. 37, No. 9, 1995, pp. 6 – 15, 32 – 38.

[16] TERI: *Climate Change: Post-Kyoto Perspectives from the South*, Tata Energy Research Institute, New Delhi, India, 1998.

[17] Ramakrishna, J.: *India's National Improved Stoves Program*, Energy Sector Management Assistance Programme Draft Report, World Bank, Industry and Energy Department, Washington, D.C. July 10, 1991.

[18] Bhattacharya, S. and Cropper, M.L.: *Options for energy efficiency in India and barriers to their adoption – a scoping study*, Discussion Paper No. RFF DP 10-20, Resources for the future, Washington, D.C. April 2010.

[19] Jaffe, A.B., Newell, R.G and Stavins, R.N.: "Technological change and the environment." In K.G. Mäler and J.R. Vincent (eds), *Handbook of Environmental Economics*, Vol. 1. Elsevier Science B.V. 2003.

[20] Newell, R.G., Jaffe, A.B. and Stavins, R.N.: "The induced innovation hypothesis and energy-saving technological change" *Quarterly Journal of Economics*, Vol. 114, No. 3, 1991, pp. 941–75.

[21] Jaffe, A.B. and Stavins, R.N. "The energy paradox and the diffusion of conservation technology" *Resource and Energy Economics*, Vol. 6, No. 2, 1994, pp. 91–122.

[22] Hassett, K.A. and Metcalf, G.E.: "Investment with uncertain tax policy: Does random tax policy discourage investment?" *Economic Journal*, Vol. 109. No. 457, 1999, pp. 372–93.

[23] Campbell, B.M., Vermeulen, S.J., Mangono, J.J. and Mabugu, R.: "The energy transition in action: Urban domestic fuel choices in a changing Zimbabwe" *Energy Policy*, Vol. 31, 2003, pp. 553-562.

[24] Davis, M.: "Rural household energy consumption: the effects of access to electricity - evidence from South Africa" *Energy Policy*, Vol. 26, 1998, pp. 207–217.

[25] Chitiga, M.: “Distribution policy under trade liberalisation in Zimbabwe” *Journal of African Economies*, Vol. 9, 2000, pp. 101–131.
[26] Mabugu, R.: “Macroeconomic effects of a devaluation in Zimbabwe: a CGE analysis” *The South African Journal of Economics*, Vol. 69, 2001, pp. 137–140.
[27] Reed, D.: *Structural Adjustment, the Environment and Sustainable Development*, Earthscan Publishers, London, 1996.
[28] ESMAP: *La Consommation de Bois de Feu a Niamey*, Energy Sector Management Assistance Programme Report, World Bank, Industry and Energy Department, Washington, D.C. 1991.
[29] Manibog, R.F.: “Improved cooking stoves in developing countries: Problems and opportunities” *Ann. Rev. Energy*, Vol. 9, 1984, 199-227.
[30] Gill, J.: “Improved stoves in developing countries: a critique” *Energy Policy*, Vol. 15, No. 2, 1987, pp. 135-144.
[31] Roden, C.A., Bond, T.C., Conway, S., Pinel, A.B.O., MacCarty, N. and Still, D.: “Laboratory and field investigations of particulate and carbon dioxide emissions from traditional and improved cook-stoves” *Atmospheric Environment*, Vol. 43, 2009, pp. 1170-1181.
[32] Johnson, M., Edwards, R., Ghilardi, A., Berrueta, V. and Masera, O.: “Why current assessment methods may lead to significant underestimation of GHG reductions of improved stoves” *Boiling Point*, Vol. 54, 1997, pp. 11-14.
[33] Bussmann, P.: *Woodstoves: Theory and Applications in Developing Countries*, PhD dissertation, Eindhoven University of Technology, 1988.
[34] Makonese, T., Robinson, J., Pemberton-Pigott, C., Molapo, T.V. and Annegarn, H.J.: “A heterogeneous testing protocol for certifying stove thermal and emissions performance for GHG and air quality management accounting purposes”, *Journal of Air & Water Management Association (JA&WMA) 2010*, In print.
[35] Karekezi, S. and Kithyoma, W.: *Implementation of renewable energy technologies – Opportunities and Barriers*, Zimbabwe Country Study, SCEEZ, UNEP, Denmark, 2001.
[36] Nepal, M., Nepal, A. and Grimsrud, K.: *Unbelievable but true – Improved cookstoves are not helpful in reducing firewood demand in Nepal*, SANDEE Working Paper No. 51-10, September 2010, Kathmandu, Nepal.
[37] Muneer, S.E.T. and Mohamed, E.W.M.: “Adoption of biomass improved cookstoves in a patriarchal society: An example from Sudan” The Science of Total Environment, Vol. 307, No. 1-3, May 2003, pp. 259-266.
[38] Mare, M. and Annegarn, H.J.: *The applicability of social marketing in the uptake of bio-energy based technologies*, Peoples Energy Network (PEN) Conference, University of Botswana, Botswana, October 2010.
[39] Ergeneman, A.: *Dissemination of improved cookstoves in rural areas of the developing world: Recommendations for the Eritrea dissemination of improved stove programme*, Eritrea Energy Research Centre (ERTC), 2003.

AUTHORS

Principal Author: **Tafadzwa Makonese** is an MPhil (Energy Studies) candidate at the University of Johannesburg. His main focus is on the development of alternative stove testing protocols for different fuel/stove combinations and the determination of trace gas and particulate emissions from these devices. taffywandi@gmail.com

Co Author: **Prof Harold Annegarn** has researched atmospheric pollution, environmental management and energy efficient housing in southern Africa for 30 years. He has supervised over thirty MSc and PhD students. His current research interests are on energy and sustainable Megacities, through the EnerKey programme in partnership with the University of Stuttgart; and the development and testing of improved domestic combustion stoves, and their contribution to air pollution reduction.
hannegarn@gmail.com

Co Author: Dr Godfrey Chikowore, is a Post Doctoral Fellow with the University of Johannesburg: Department of Geography. He is specialized in Social and Economic Geography: regional economic cooperation and integration. He has published extensively through chapters and monographs on regional economic integration. He has received international awards for research in regional cooperation and development studies. His current research is to culminate in a reference book on *Regional Cooperation in Developing and Developed Countries.*
godchik60@yahoo.co.uk

Presenter: The paper is presented by Tafadzwa Makonese.