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Energy Leapfrogging in Developing Countries a Reality or Pipedream: The Case of Chiwundura Communal Area in Zimbabwe

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ABSTRACT Households in Chiwundura Communal Area continue to depend on traditional energy forms such as fuelwood, which are difficult to collect and also cause indoor pollution. Households were expected to be using modern energy forms such as electricity and liquefied petroleum gas (LPG).In the process they would skip intermediate energy forms such as paraffin. The study utilised mixed research paradigm to collect data. Participants possessing relevant information were purposively sampled. Questionnaires, interviews and observations were used. The study established that several households could not leapfrog because of depressed incomes. Households also continued to use traditional energy forms because of cultural factors. Traditional energy forms were multi-purpose, and were used for cooking, space heating and preserving food. The study recommends that households should be made aware of dangers of biomass energy and benefits of modern energy. Stakeholders should try to avail modern energy forms so that they become accessible and affordable.

INTRODUCTION

According to the International Energy Agency (IEA) (2015) nearly 2.7 billion people which is almost 40 percent of the global population, are exposed to energy poverty as they depend on biomass fuels (such as fuelwood, charcoal, animal dung and agricultural residues) for cooking, boiling water and heating. Half of the people exposed to energy poverty are living in the developing world. The number of people who use solid fuel however increases to 3 billion if coal is included (Practical Action 2014). The continued reliance on biomass on traditional energy forms has several disadvantages. Nearly 2 million people worldwide die each year from inhaling the lethal smoke from kitchen stoves and fires (Practical Action 2014). Women and children under the age of five who spend several hours a day close to fire are disproportionally affected by indoor air pollution (Fullerton et al. 2008; Warwick and Doig 2004). According to Balmer (2007) people in developing countries particularly women are exposed to a number of health problems such as back and neck injuries associated with carrying heavy fuelwood loads. On top of that they walk long distances dealing with risky and hazardous environments as they gather biomass fuels. According to Cecelski (2001) the Food and Agricultural Organisation estimates that 60 per cent of rural women in Africa, 80 per cent in Asia and 40 percent in Latin America spend between one and six hours a day in fuel scarce areas. Proponents of development content that the plight of these people could be alleviated if they adopted modern energy forms and move away from the use of traditional energy forms (Marlow 2009; Miedema 2008; van Benthem 2010). This could be achieved through energy leapfrogging.

Leapfrogging has become a buzzword in the energy adoption process. Energy technology leapfrogging involves moving from one technology to another without going through certain intermediate stages. For example, a household can move from using biomass fuels (dung, crop residues, and fuelwood) or coal in the traditional, inefficient and polluting stoves to efficient liquefied petroleum gas and electric stoves which are at the top of the energy ladder, while bypassing the transitional energy services such as wind energy and improved charcoal and kerosene stoves (Gallagher 2006; Goldemberg 2006; Goldemberg et al. 2001; Burke 2011; Lewis 2007; Marlow 2009). In essence this process involves the deployment of a new technology in an application area where at least the previous version of that technology has never been deployed (Sauter and Watson 2008). Donev et al. (2018) argue that leapfrogging could be looked at as the ability of a developing or less developed country to essentially "skip" less efficient and higher carbon-intensive technologies during the course of their development. Murphy (2001) contends that leapfrogging promises to bring modern energy sources to rural people quickly and in a cost effective manner. In other words, leapfrogging is viewed as a way of catching-up with current technology. The leapfrogging route is depicted as clean and sustainable.

Energy leapfrogging is however hindered by a plethora of factors. The majority of households in the developing countries lack the finances to acquire modern technology. According to Amankwah-Amoah (2015) the majority of people in Africa who are in desperate need of solar power cannot afford such an investment because of high upfront costs. Murphy (2001) contends that the adoption of energy technologies is affected by lack of independent and successful entrepreneurs and enterprises producing, marketing and servicing the modern energy technologies such as electricity and liquid petroleum gas. Gallagher (2006) also posits that leapfrogging in developing countries is limited by lack of technological capabilities to produce or integrate the advanced energy technologies themselves. This forces them to continue to buy modern energy technologies from industrialized countries, usually through licensing or joint-venture arrangements. It is therefore restrictive to rely on imported technology. High prices also hamper the adoption of modern energy technologies. According to Schlag and Zuzarte (2008) and Daurella and Foster (2009) LPG is almost inexistent in rural areas of sub Saharan Africa because of high prices except for very few countries namely Gabon, Senegal, and Mauritania which have adopted the use of LPG. D'Sa and Murthy (2004) posit that the upfront cost for procuring the stoves and cylinders tend to make LPG heat delivery system unaffordable for low-income groups, even at subsidised rates. Goldemberg et al. (2004) have concluded that worldwide LPG is affordable by more affluent households.

Statement of the Problem

Households in Chiwundura Communal Areas in Zimbabwe continue to depend on the traditional biomass fuels for cooking, space heating and lighting, boiling water as well as other economic activities. This is in spite of the availability of modern energy services such as electricity and solar energy. Households were expected to bypass the transitional energy services such as paraffin and adopt the modern energy forms. This is, however, not the case as very few households use modern energy entirely for cooking, space heating and lighting, and boiling water.

Research Questions

In the quest to understand why there was very limited energy leapfrogging if any in Chiwundura Communal Area the study utilised the following questions.

- What are the fuel types used in the communal area?
- Why is there limited energy leapfrogging in the communal area?
- How can access to the households be improved in the communal area?

Theoretical Framework

This study was based on the energy leapfrogging model. The model postulates that developing countries could adopt modern energy services that are currently being used by the developed countries without necessarily passing the stages followed by the latter countries. Instead of progressing from the traditional energy services through the transitional energy services to the modern energy services, the developing countries may skip the transitional stage. In other words, the developing countries will leapfrog from using fuelwood, dung and crop residues to using efficient liquefied petroleum gas and electric stoves. In the process they bypass the intermediate energy stage comprising of wind energy and improved charcoal and kerosene stoves (Burke 2011; Goldemberg 2006). Energy leapfrogging involves the deployment of a new energy technology in an application area where at least the previous version of that technology has never been deployed before (Sauter and Watson 2008). The model is regarded as a new energy paradigm with the capacity to solve the global energy crises (Saygin and Cetin 2010). The world particularly the developing world is faced with a number of challenges such as deforestation, climate change, soil and water pollution. Development practitioners and planners believe that the adoption of energy leapfrogging will solve the aforementioned problems.

METHODOLOGY

The study which was conducted between January and March in 2018, utilised the pragmatic approach by triangulating qualitative and quantitative techniques in the collection of data. This was necessitated by the desire to increase validity and credibility of the results obtained on energy leapfrogging in Chiwundura Communal Area. Triangulation was critical as the two techniques were used to complement each other. This increased the depth of understanding of energy leapfrogging issues. The use of questionnaires was critical as the statistical figures generated validated the findings. The qualitative methods used, that is, the interviews, focus group discussions and observations enabled the researchers to observe the social life of households in the study area, and be where the energy was being used. The study adopted the case study approach, which allowed the researchers to investigate energy leapfrogging which is a contemporary phenomenon within its real life context. The approach provided a better understanding of why rural households in the study area could not leapfrog. A total of 215 households from a total of 3428 households (ZIMSTATS 2012) were both purposively and conveniently sampled from the four wards in the study area. These methods enabled the researchers to select places and people deemed relevant to the study.

Study Area

Chiwundura Communal Area is located in Vungu Rural District also known as Gweru Rural District which is in the Midlands Province of Zimbabwe. It lies about 45 kilometres North East of Gweru, which is the provincial capital, and about 40 kilometres South East of Kwekwe as shown in Figure 1.

It is situated between 29°E and 31°E and 18°S and 20°S. The communal area has four wards namely Gambiza (Ward 10), Mutengwa (Ward 11), Gangira (Ward 12) and Masvori (Nyabango) (Ward 13). Wards 10, 11 and 12 consist

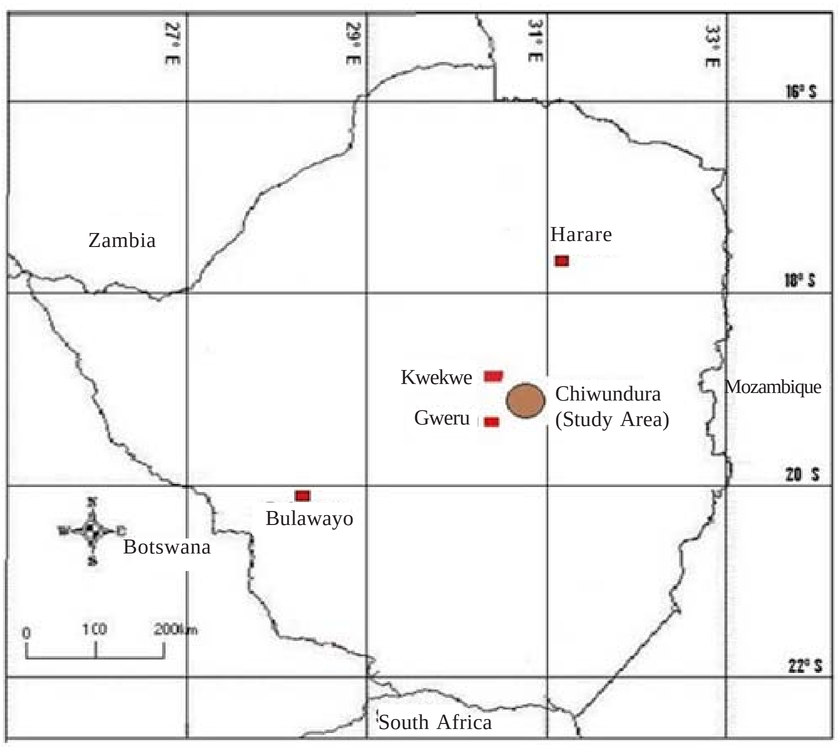

Fig. 1. Location of Chiwundura Communal Area in Zimbabwe

of the traditional rural areas (formerly known as tribal trust lands), that were established during the colonial era. The dwelling units in the communal area were a combination of traditional dwelling units and mixed dwelling units. The former were the old style family settlements in which buildings were made of pole and dagga (these were on the decline) and in some cases brick, with thatched roofs, while the latter were found in the old style family settlements where one or more of the buildings in a cluster were built of modern materials such as bricks, asbestos or zinc roofing sheets and tiles. The communal area is located in Agro-ecological Region III and IV, and the majority of households depend on subsistence agriculture for their livelihoods.

FINDINGS AND DISCUSSION

Household Energy Portfolios in Chiwundura Communal Area

Communities in Chiwundura Communal Area depend on a variety of energy services for cooking, space heating and lighting, entertainment, communication and other economic activities such as bread baking, brick making, pottery and beer brewing. This study focused on cooking, space lighting and heating which are the key activities in the area. The observations made were that households used traditional biomass energy (fuelwood, dung and crop residues), transitional energy services (paraffin/kerosene) and modern energy services (electricity, solar and diesel powered generators). Table 1 shows the different energy services used by the sampled households in four key areas. The figures are expressed as percentage of the total number of sampled households.

Information in Table 1 shows that the majority of the sampled households relied on biomass energy services and in particular fuelwood for most of their energy needs. It was observed that very few people were using grid electricity, gensets and solar. Those who had connected their homes to grid electricity used it mainly for lighting instead of cooking. It was also realised that households using grid electricity did not abandon biomass energy services completely. Instead they had adopted an energy mix whereby they were using it together with other energy services. They considered grid electricity as more expensive than fuelwood which they said was freely available.

It was observed that although fuelwood was the dominant energy service in use, it presented a number of challenges. People walked long distances in search of fuelwood as it was becoming scarce due to deforestation. Although fuelwood collection has gender dimensions, men were gradually getting involved in this activity. This was due to the long distances involved and also due to the fact that either ox-drawn or donkey drawn carts were being used for fuelwood collection. This task was more suited to men than women. The use of fuelwood caused serious indoor air pollution. Women respondents were oblivious of the harmful effects of pollution from the smoke. It was apparent that quite a number of women and children were showing symptoms of smoke related ailments. This prompted the researchers to find out why households could not move up the energy ladder.

Barriers to Energy Leapfrogging

Income

The majority of sampled households in Chiwundura Communal Area could be easily classified as poor. The study established that household income was the major deterrent to energy leapfrogging. The majority of the sampled households (58.6%) depended on peasant agriculture for their livelihoods. A few households (7.4%) were in formal employment, while 25.6 percent were self-employed. The remaining 8.4 percent

Table 1: Energy use in Chiwundura Communal Area

Use/type	*Fuelwood*	*LPG*	*Solar*	*Grid Electricity*	*Candles*	*Gensets*	*Dung*	*Kerosene*
Cooking	82.8	1	-	16.6	-	-	-	-
Heating water	89.8	-	-	9.3	-	-	0.9	-
Space heating	91.2	-	-	6	-	-	2.8	-
Space lighting	7.8	-	6	24.2	9.8	2.9	-	49

Source: Research Data, 2014

depended on income from remittances from relatives working outside Zimbabwe. Chiwundura Communal Area was situated in Agro-ecological Region IV, which was prone to severe seasonal drought. On top of that the soils in the areas were old due to several years of tillage. Over the years, agricultural land allocated to households have become smaller because of population increase. As a result, most households were not able to produce excess maize for sale. This therefore meant that such households had little disposable income, which was divided among the several needs such as education, food, clothing, and health. It was almost impossible for the majority of peasant farmers to afford switching over to modern energy services such as grid electricity and solar household systems.

The situation was worsened by the fact that most modern energy services were priced beyond the reach of ordinary peasant farmers. Interviews conducted with some of the residents in Chiwundura Communal Area revealed that the majority of the poor households could not afford to be connected to grid electricity as this required a huge financial investment. The rural electrification programme introduced by the Government of Zimbabwe was only restricted to bringing the electric cables into rural areas. The task of connecting electricity to homesteads was left to individual households. Although the government initially met part of the electrification costs at the time of the study households were expected to meet the full cost on their own. It was observed that banks were not willing to finance the electrification projects as households did not have any collateral hence without guarantee that they would be able to pay back the loans advanced to them. During focus group discussions households revealed that they could not commit their cattle as collateral as this was their source of livelihood. Respondents revealed that the initial connection fees and house-wiring were beyond the means of ordinary peasant farmers. Information obtained in the study area showed that the Zimbabwe Electricity Distribution and Transmission Company (ZETDC) demanded an upfront connection fee of US$95 together with a deposit fee of US$45. On top of that on average house wiring cost US$200. Those households that were able be connected also faced other problems such as acquiring the requisite appliances such as cooking stoves. Although 22.8 percent of the sampled population were connected to electricity only 6 percent of the sampled population were using electricity for cooking. They argued that it was either expensive to use electricity for cooking or they could not afford the appliances. Others could not afford the monthly bills, resulting in them being disconnected. Observations made in the study area showed that several households back-switched to the traditional biomass energy forms as they could not afford reconnections or the monthly bills.

The study further established that most houses in Chiwundura Communal Area did not meet the electrification standards set by ZETDC. Quite a number of houses were simple structures some of which were grass thatched while others did not have watertight roofs as required by ZETDC. Even if the grid connection was to be provided for free it was practically impossible for the majority of households to pull down their houses and build those complying with ZETDC regulations. Participants in this study acknowledged that they had very limited opportunities to raise extra funds which they could dedicate to electrification. The available funds had a number of commitments which included school fees, food and health requirements.

The inadequate energy production at national level has affected access to electricity at village level. These ripple effects have tended to discourage energy leapfrogging in Chiwundura Communal Area. Zimbabwe was producing an average of 1200 MW against its potential of 1800 MW, while it required 2200 MW (Rafemoyo 2010). As already mentioned earlier on there was evidence of rural electrification with cables and poles in place in the study area. Power outages and load shedding have tended to portray a negative picture on availing modern energy forms in the area. Vandalism of ZETDC transmission equipment such as transformers, overhead and underground cables, bolts and nuts, guy grips and washers also worsened the situation. ZETDC infrastructure was old and obsolete which meant there were numerous breakdowns. This situation did not encourage the extension and expansion of the rural electrification programme. Some respondents in the focus group discussions argued that it was unnecessary to adopt grid electricity when it was fraught with such challenges. They did not have confidence in the power utility and the modern energy service it provided. They felt they could only leapfrog to modern energy if there was a guarantee that grid electricity would be supplied without any hitches.

A similar situation was noticed with the use of liquefied petroleum gas and solar house systems in the study area. Initial cost of installing a solar house system was generally beyond the means of most of the households in the study area. According to Kairuki (2018) the initial capital cost of renewable energy is relatively high when compared to conventional sources of energy, and this tends to raise the cost of renewable energy generation. Bradford (2006) concurs with this by saying almost ninety percent of the lifetime cost of a solar PV system is paid up-front" at the time of installation, which is beyond the reach of most people in Africa. The situation is exacerbated by government which do not have the capacity to finance the spread of new energy technology (Amankwah-Amoah 2014). Interviewees revealed that they could not afford LPG tanks as they were priced beyond their use. Only 5.1 percent of the respondents used LPG for cooking and incidentally these people were also connected to grid electricity as was established through cross tabulations. They used LPG when there were electricity blackouts. Those who did not use LPG said upfront costs for stoves and cylinders and the process of refilling the cylinders were rather beyond them. They found it cheaper to continue relying on biomass energy which according to them was freely available.

Energy Availability

Energy availability played a critical role in determining energy leapfrogging in Chiwundura Communal Area. Although households in the study area desired to use grid electricity, LPG and solar household systems, they could not do so as these were not immediately available. The government embarked on the rural electrification programme in Chiwundura Communal Area but not all areas had been covered at the time when this study was conducted. Information obtained from the power utilities (ZETDC and REA) that were tasked with the responsibility of bringing power to the communal showed that they were incapacitated by lack of funds and equipment. According to the REA Midlands Regional Engineer the process of electrifying the whole communal area was delayed by high infrastructural costs. The situation was exacerbated by the low household density as this made the supply of electricity to the area more expensive than anticipated.

The unavailability of LPG in the study area also affected leapfrogging from the traditional biomass energy services to this more efficient energy service. There was not even a single LPG refuelling station in the study area. The nearest LPG refuelling stations were available in Gweru and Kwekwe. These were approximately 40 kilometres and 45 kilometres away respectively from the study area. Households had to travel to these cities to either purchase or refill canisters. Since most households did not have their own transport it was difficult to transport refilled canisters. Public transporters were wary of transporting canisters on their vehicles as they were associated with explosions and fires. Respondents also mentioned that they did not have a capacity to procure LPG in large quantities. They could afford between 3 and 5 kilograms. This however did not make economic sense to travel a distance of 40 to 50 kilometres to procure LPG in small quantities. The process of transporting canisters was therefore a major hindrance to leapfrogging. At national level Zimbabwe did not manufacture its own LPG. All the gas that was used in Zimbabwe was imported from South Africa and this had a bearing on the availability of gas to other parts of the country including the study area. This is why Batinge et al. (2017) argue that there should be an internal financial commitment to undertake renewable energy investment beyond what is received in aid and donations from development partners. Most governments in developing countries do not want to commit themselves to make new technology available.

Energy Accessibility

It was established that accessibility to modern energy was critical in energy leapfrogging. Accessibility can be viewed from two angles. The first type of access is related to the cost of fuel service and this was covered earlier on. The second type of access refers to the physical accessibility and is concerned with the distance to the nearest energy source. The study observed that areas such as Nyabango, St. Chrsitopher and parts of Gambiza Ward were remote. They were located at least twenty kilometres from the nearest grid lines. Lack of access inhibited them from being connected to the grid; hence households with the potential to leapfrog could not do so. As already mentioned earlier on homesteads in the remote parts of the study area were scattered making it difficult for the power utility ZETDC to connect them to the grid. According to information obtained from both ZESA and REA the cost of building a distribution network to serve such isolated homesteads was beyond what the government and utilities could afford. The same situation also affected access to LPG. It was difficult and expensive to transport LPG to the remote parts of the study area where market was not guaranteed. The inaccessibility of modern energy services acted as an impetus to the continued dependence on biomass energy service. Leapfrogging could not occur in such an environment.

Cultural Practices Associated with Meal Preparation

Energy leapfrogging in the study area was affected by socio-cultural practices associated with meal preparation and cooking. According to Bank (2010), fuels are encoded with a multiplicity of social meanings and social associations which may be culturally defined and tend to determine the context in which the fuel was used. Most of the traditional foods in the study area required slow heating. These included brown rice, cow trotters and *rupiza* (porridge from cow peas). This could be achieved using fuelwood. Taste preferences and the familiarity of cooking with traditional biomass energy made it difficult for energy leapfrogging to take place.

During focus group discussions participants argued that food cooked with traditional fuels was tastier than food cooked with modern fuels. They gave *sadza* (thick porridge) a staple in most homes as a typical example. They went on to say that food cooked with traditional fuels remained hotter for longer periods than food cooked over an electric stove. Information obtained during focus group discussion showed that round pots as well as three legged pots could only be utilised using the traditional fireplace. The traditional fireplace also offered a social and ritual focus as families sat around the hearth after evening meals. This was critical for family bonding. In this regards cultural practices and taste hindered energy leapfrogging. The above views are in conformity with the views by Batinge et al. (2017) that in order for leapfrogging to occur the market should be ready to accept the new technology. Jacobson (2016) also concurs by saying that barriers to leapfrogging are neither economic nor technical, but social and political. Households tend to hold onto practices and beliefs that hinder them from upward progression in terms of energy.

Lack of Information

Lack of reliable information on the advantages derived from using modern energy services affected their adoption especially in the developing countries (Mohamed and Lee 2006). In Chiwundura Communal Area several households were reluctant in having their homes electrified when the first phase was instituted in the area in the early 1980s. They thought electricity was expensive and was intended for the elite. As a result they failed to benefit at that stage when all the expenses were being met by the government. Information obtained through focus group discussions showed that households have always been sceptical of the rural electrification programme and had developed a wait-and-see attitude. LPG has failed to penetrate large parts of Chiwundura Communal Area and this was attributed to lack of information. The government and development agencies had not made any effort to popularise LPG. Instead it had been stigmatised as it was associated with explosions and fires. Kariuki (2018) feels that rural communities may find it hard to leapfrog to better renewable energy technologies and systems because they lack of knowledge and awareness. This retards the development of renewable energy technology.

It was observed as already mentioned earlier on that most of the households that continued to use biomass energy services were not aware of their health implications. Several people in the study had complained of chest, neck and back pains at one time or another. These ailments were closely associated with the use of biomass energy services. The study also established that there were a number of people who had cataracts. This is another problem which had very close association with the smoke emitted in the kitchen. The respondents revealed that they were not aware of the dangers that were likely to be caused by indoor air pollution. These included deaths of women and children below the age of five who spend most of the time close to the fire. It is therefore important for households to switch to modern forms of energy as these have positive health impacts as opposed to biomass energy forms. Donev et al. (2018) view the ability to cook with electricity instead of biomass fuels as having a positive impact on the health of a family, especially that of women and children who spend the most time in the kitchen. The use of electricity in cooking removes the dangers caused by the by-products that result from the combustion of both liquid fuels such as kerosene and solid fuels such as charcoal (Donev et al. 2018).

The researchers therefore feel that once the households are equipped with knowledge on the advantages of modern energy forms, they may want to leapfrog to modern energy form. Sauter and Watson (2008) contend that some households lack the necessary knowledge on the use and operation of a new energy technology and this frustrates any attempt to leapfrog to the best available technology. This has to be accompanied by the provision of funds to acquire the modern energy services. Households in the study area could not therefore practise energy leapfrogging as they lacked concrete information on modern energy services.

Skilled Manpower

Energy leapfrogging in the study area was hampered by the unavailability of skilled manpower to develop, install, operate and maintain technology. In particular, there were no technicians to deal with solar house systems and diesel powered generators. Most of the so-called technicians were self-taught; hence they could not deal with more complicated faults. During the study several dysfunctional solar systems and generators were observed in numerous homes. This state of affairs tended to discourage potential users of the modern technology. This was in conformity with observation made by Amankwah-Amoah (2014) that governments in the developing countries did not have the capacity to train manpower to install the new technology. Kariuki (2018) contends that lack of trained personnel to train, demonstrate, maintain and operate renewable energy structures, especially in regions with low education levels, tends to discourage people from importing the technologies for fear of failure. The situation was worsened by the influx of counterfeit products especially the solar home systems and diesel powered generators. As those had limited lifespan the respondents felt it was better to continue relying on traditional biomass energy as well as paraffin lamps instead of wasting money on counterfeit products.

CONCLUSION

The majority of households in the study area were unable to have any leapfrogging in their use of energy. Most of them had depressed incomes. The cost of modern energy forms was beyond the reach of most households. It was observed that some of the modern energy services were not available. In some cases, households did not have knowledge and information on the modern energy services. Households in Chiwundura Communal Area will continue to depend on the traditional biomass energy services for an unforeseeable future as their situations do not allow them to access modern energy services. It is therefore critical to recommend realistic options and strategies that are workable with the poor.

WAY FORWARD

There is need for education and awareness campaigns on the importance of adopting new energy technologies. Stakeholders such as the central government, nongovernmental organisations and development practitioners should embark on useful and correct information dissemination on the availability, uses and benefits of the different modern energy services such as LPG. There should be a deliberate effort to avail sustainable modern energy services such as the LPG and solar in the communal area. This coupled with provision of funding will enable peasant farmers to leapfrog to greener energy services. There is need to have housing interventions whereby schemes could be put in place to assist in constructing affordable rural houses that are compliant to electrification codes. There is also a need for authorities to be strict so as to stem out the importation of counterfeit products.

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