Impact Of The Use Of Biogas In Rural Communities In Zimbabwe.

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Abstract

The paper reviews the impact of biogas use in rural communities in Zimbabwe. A comparative study between the use of firewood and the use of biogas can be done. The paper discusses the historical developments in the use of biogas to date. The use and cost of energy and power is assessed to identify options to replace with biogas. Possible replacement of natural gas and firewood usage is also considered. The different and main feed stocks for biogas are discussed with a view to determine feed stock options for Zimbabwe. The challenges around the use of human waste for biogas are examined in terms of perceptions and cultural aspects. A case for biogas use is developed to justify the need to use it since it is a renewable energy. The production of biogas in bio-digesters and biogas plants in different parts of the world is considered to provide possible benchmarks. A discussion of the climate change impacts of biogas use and the mitigation options are presented. Finally, research gaps are identified paving way for future studies. The proposed future studies will focus on these reviewed aspects and research gaps with a view to fully study the impacts of the use of biogas in rural communities in Zimbabwe.

Keywords:
biogas, bio-digesters, environmental impacts; environmental management, technology adoption

Introduction and background

The Flemist and physiologist Jan Baptist van Helmont discovered biogas in 1630. The gas was coming from decomposing organic matter through combustion process. It is a mixture of primarily methane, carbon dioxide and hydrogen (Bond 2011). The gas is flammable. The first biogas digester construction took place in 1859 in Bombay, India. Thereafter, the Victorian England used sewer gasses for streets lights. German started feeding biogas into public gas supply in 1920 and built large agricultural biogas plant that initially operated in 1950. In 1970s, the use of biogas gained momentum when there was high oil cost that led to alternative energy sources (Ni and Nyns 1996). China promoted biogas use in all rural families and facilitated installation of more than seven million digesters (He 2010). The government of china subsidies the construction of nearly four million family sized biogas plant (Indian government 2007).

The cost of other source of energy is very high, as global demand for energy is increasing daily hence there is decreasing availability of fossil fuels. However, most of the countries are experiencing load shading and availability of grid electricity is now a big concern worldwide especially in developing countries (BMUB 2017). In 21 Sub Saharan countries, for example 10% of Zimbabwean population has access to electricity. Zimbabwe generates about 1300 megawatts (MW) hence its requirement is 2200 MW. It imports 100MW from Zambia, 300MW from South Africa, Eskom and 40MW from Mozambique in 2012 (BMUB 2017). According to energy policies and management, the world market energy utilization was forecasted to increase by 44% between 2006 and vision 2030 (Thran et al. 2018). Greater population of developing countries depend on firewood and by so doing thus leading to deforestation and desertification (Yakubu

2010). Towns are also consuming firewood and cause environmental degradations as there is high town people migration from rural communities (Barau 2006).

Use of biogas can change the world as noted by Akingbami et al, (1996) in Mshendete and Parawira (2009), that feedstock substrate for an economically feasible biogas in Nigeria that include water, lettuce, water hyacinth, dung, cassava leaves, and processing waste, urban refuse, solid industrial wastes, agricultural residues and sewage are good source of biogas. The big challenge is adoption by most people to use gas. World environment can be saved by alternatively move to biogas energy use. The choice of environment friendly energy option is a giant step forward in arresting the menace of desert encroachment in sub Saharan Africa in particular and climate change at the global scale (Zakariya'u 1999).

The Potential to Substitute Natural Gas with Biogas

African developing countries use cookers, lamps, refrigerators and engines fuelled by gas (ISAT/GTZ, 1999a). Biogas convergence into electricity is achieved by use of fuel cells hence clean gas and the cost of fuel cell has to be considered (Dimpl 2010). In Peru, India a well modified diesel engine was fuelled by biogas digester to operate electrical generator (Reddy 2004). However, biogas has advantage energy source use in rural areas of developing countries because of its clean blue flame seen from stoves (ISAT/GTZb). According to Itodo et al. 2007; ISAT/GTZ, 1999b noted that biogas stoves efficiency was 20% - 56% though can be affected by conditions and stove design. World health organisation (WHO) also noted that over three billion people use solid fuels such as wood, dung, coal and agricultural residues to supply their energy needs (WHO 2011). This result in polluting the air and contribute to climate change thereby need to promote biogas energy.

Smith (2012) noted that biogas technology has a greater potential to substitutes wood energy consumption hence has a greater opportunity for household energy sustainability. This has an advantage to household members to venture into other socio economic activities. Also Wamuyu (2014) said biogas production process is carbon neutral and does not add or remove carbon dioxide from the atmosphere hence imperative way of mitigating climate change. Biogas has advantage of no smoke in the house thereby saving women and children from respiratory distress and aliments. Biogas is a renewable energy source comes from anaerobic digestion process in treating biodegradable matter and is a simple way of managing waste (Dahiya and Josephy 2015; Mata- Alverez et al. 2014).

Perceptions on the use of Human Waste for Biogas Production

With all the benefits of using biogas, there is a gap between behavioural attitudes or perceptions towards using human wastes as source of biogas in Ghana. Oteng-Peprah et al., (2019) argued that the perceptions among the public on issues are critical as an integral part of any success in new innovation or project implementation. For a new technology to be accepted, it is important to look into the people's pecerptions so as to penetrate them successfully. This is in line with Gibson's 1979 as cited by Mariwah and Drangert, 2011) assertion that perceptions determine our behaviour and what we perceive determine what we do next. Tradition, religion and culture are barriers to the adoption of biogas technology. According to Shane et al., (2015) found that the biogas adoption was affected by traditional beliefs in Lusaka Zambia. The research is finding out the gaps that are leading to lack acceptance of biogas which result in deforestation and cause effects of climate change. The solutions to bridge the gaps shall be brought to restore the environment and introduce a simple way of using biogas by communities.

The Justification for Biogas Use

Vegetation has been gradually destroyed by humans through cutting down of trees for firewood use as a source of energy by most communal people. This has an effect on climate change hence more hazards such as cyclones, droughts, heat, snow, veld fires, earthquakes, pests and diseases of both crops and animals, are encountered and lead to death of humans and its ecological symbiotic creatures and land degradation that

eventually affect surface water bodies. Erratic rainfall is affecting small agricultural farmers who are not into irrigation.

The communities will play a major role in restoration of environment in various areas by transition from using firewood to biogas energy. People learn how to make their own biogas using crop and animal wastes from their locality thereby serving trees. They should practice afforestation. The rejuvenated land will reduce effects of climate change. Soil, trees, natural ecosystems will be conserved. Siltation of water bodies will be reduced hence improved water life and recreations. Use of biogas will reduce ozone layer depletion hence increase greenhouse effect. Natural hazards such as cyclones, droughts and pests and diseases will be minimized and improve the natural environment for the benefit of future generations.

Biogas and Major Feed Stocks for Biogas Production.

Biogas is a composition of methane (60-70%) and carbon dioxide (30-40%) that comes out from process of gas combustion under anaerobic fermentation of organic matter in the presence of methanogen bacteria. Biogas is good to replace rural and some urban source of energy such as wood, hard charcoal, kerosene, plant residues and propane (Olugasa et al. 2014). UNEP (2010) noted that African forest loss is due to firewood. The women participate very well in fetching firewood hence are affected much in energy crisis (Amigun et al., 2012; Smith et al. 2005).

With reference to IEA world Energy Outlook (2019), Europe and United States gas infrastructures release 50 -100% more energy to the end users than electricity grids. However, natural gas used to turn turbines that produce electricity as a dispatch able source of electricity. This also indicates the importance of gas. Cassava has classified as the third largest crop that has residues that used in the fermentation industry to produce biogas (Fubao et al. 2010). Most African countries' economy is based on agriculture both livestock and crop production. This brings the advantage of having biogas as a major source of energy as the materials are readily available. Forhad et al. (2013), indicated that water hyacinth, a waterweed in most lakes is a good source of material to use to biogas production. By using this waterweed, the product is gas as well as water conservation for other domestic and industrial use. Homemade gas plant is easily to establish. Ravi and Tiwari (2013) investigated that the kitchen wastes are good for biogas making by rural people. This has advantage for adoption by communities.

Laboya et al. (2009) did an investigation on importance of biogas as a source of energy and found that there was high amount of gas produced from various feed-stocks. Another research conducted in the laboratory scale experimental design by use of agriculture wastes to show the effects of alkaline to determine the volumes of gas from pineapples, plantain and cassava peelings as the feedstock gave the results that indicated high volumes of gas produced under moderate alkaline conditions. The temperature ranged from 27 -35.5°C. The condition is easily maintained and no use of other expensive technique. Pig wastes are readily available as there are so many farmers who are into piggery industry. The manure contains20-25% dry matter while the organic dry matter content totally to 75-80%. According to Sonderiysk Biogas Bevtoft (2018), Denmark is processing 600 000t of slurries, straw and residues converted to 21m3 of bio methane. However, the yields can be increased by 70% by use of power to gas together with pyrolysis. This can happen in developing countries of Africa.

In Poland, corn silage and manure were used as raw materials hence had a very big potential to produce biogas. The combination of corn silage, slurry and glycerine increased the calorific value (Romaniul and Domasiewicz 2014). This shows how other European countries have moved on the use of gas and save natural plant species. Methane generated from natural gas or biogas when fed into engines along with diesel, was found to reduce nitrogen oxides and particulate matter but increased knocking at high loads and misfire at light loads. (Jaber and Noguchi 2007). Most African communities rely on both crop and livestock production hence can easily venture into biogas energy use as raw materials are readily available.

Biogas Digesters and Plants

Types of digesters that can be used by people include covered lagoon, plug flow and complex. Covered lagoons are man -made and can work with slurry where biogas is trapped under a cover. These types are not heated hence during winter time or cold weather conditions, the gas flow is reduced. Advantage of this type is that they are easy cheap and reduce odour even under low temperature climates (Park et al. 2002). The second one is plug flow digester which is very useful in livestock farmers. They have long relatively narrow, heated tanks with a gas tight cover (Lusk 1998). However, manure has to be fed to continuously supply of the gas (Picket and Sieber 2005). Third one is complex mix digester is built of a reinforced concrete tank heated and tightly sealed. This type is a bit expensive to install and needs high maintenance cost. As this type is heated all year round, the gas output is stable (Pillars & AgSTAR 2006).

In Germany, there are lot of biogas plants that are in operation and be the largest in the world (Sheftelowits et al. 2018). An important study was carried out in Germany where crop residues were used to generate biogas and later noted again that the remains from biogas digester was used as fertiliser again in crop production (Thran 2019). The energy crops dominated by maize silage (72%) and grass (12%) depending on the plant size gave more biogas energy. Small plants use more manure than large plants that use more energy crops, (Daniel et al. 2017). These shows how important are crops in the biogas production.

Climate Change Mitigations Against Biogas Use Impacts

Afforestation plays an important role in the restoration of an area that has been destroyed due to previous overuse of the land or to reduce the amount of soil erosion in the soil in an area and establish a more stable soil base (Mubaiwa 2021). To reduce effects of climate change on natural disasters, people should plant trees on their homesteads. In Zimbabwe, there is national tree planting day that targets millions of trees planted per annum. Pressure is mounting against the use of methods that destroy the environment when curing tobacco by people who use firewood. In reducing the environmental degradation, biogas use in rural communities plays a vital role.

The researchers are targeting rural communities in Zimbabwe to explore ways that can be use to move them from using firewood to adopting biogas as a way to conserve natural resources. For future studies selection of respondents will be more effective if it is done through consultations with the village heads. The selected people will provide data through interviews, direct observations, secondary data and questionnaires filling. This sampling method will ensure full geographical coverage and improve sample representativeness.

Research Gaps and Study of Biogas Use Impacts in Zimbabwean Rural Communities

There is plenty of biogas use and impacts data that exists in different government institutions, non-governmental organisations and research institutions that has not been analysed to sift out useful information. It is necessary that scientific data analysis be done. Data analysis to be done can include an application of statistical and techniques to describe illustrate, evaluate, categories and summaries data from the field (Yin, 2011). Additionally more data can be collected for up to 300 respondents. It has been found that respondents generally openly provide their knowledge on availability of firewood and gas energy sources in their communities in other studies done. (Gwimbi and Dirwai 2003).

There is a paucity of studies on biogas use and its impacts in Zimbabwe of data gathered from interviews of key informants. This is as gap that needs to be addressed, A key informant interview is a qualitative in-depth interview discussion with resourceful persons with knowledge in the society (Astride Stirling 2001). Data collected from key informants will supplement data collected through questionnaires. Yin (2011) also supported key informant interviews as a way of using profound knowledge and experience in gathering data.

In Zimbabwe there has been very few studies applying scientific observation methods in gathering data on biogas use and impacts. Rigorous and scientific observation methods need to be applied in this area through observation of people already using biogas energy. Useful information from these experienced users can assist to conclusively provide insights on biogas use and its resultant impacts in Zimbabwe. The information will help communities to venture into the use of biogas as an alternative to firewood. It has been observed so far that the culture in the Zimbabwean communities is to gather large piles of firewood. This is decimating trees and substitution by biogas made for biomass waste and animal droppings can assist to reduce deforestation. An advantage of using biogas over firewood is implied and will be studied. Yin (2011) pointed out that direct observations help researcher to capture real events to provide evidence. Primary data can be collected to inform the research objectives.

A lot of secondary data on biogas use and impacts exists in Zimbabwe and worldwide. This is the data already collected for other purposes. De Vaus (2001) indicates that secondary data has to be refined. Reports from non-governmental organizations are useful to check information such as areas using biogas, firewood, and the adoption rate. Secondary data collection and analysis will be useful to complement data from questionnaires, interviews and direct observations.

Conclusion

This paper has developed a strong background that has traced the chronological discovery and development of biogas over the centuries. It discussed its potential to replace other forms of energy, the justification of its use and the barriers associated with biogas use especially cultural perceptions on biogas from human waste. The deployment of bio-digesters and big biogas plants worldwide has been discussed with a view to identifying feasible options for Zimbabwe. Similarly, the different types of feed stocks for the production of biogas have been examined to guide the work on biogas potential in Zimbabwe using similar and other feed stocks. Some climate change mitigation and adaptation options have been indicated especially the option for reforestation.

In the process, a number of research gaps have been identified, paving way for future research work by the researchers and by other players in the research area of biogas use and its impacts. Currently exising data needs to be codified and analysed. Data gaps identified require than a number of scientific research methods, qualitative and quantitative be used to address them. The preliminarily gathered information and results can be implemented in different communities in Zimbabwe, Africa and globally to reduce climate change impacts such as deforestation, siltation, cyclones, heat waves, and pests and diseases outbreaks. Biogas energy production and use can dominate and be used as fuel, bio-oils, bio-power and in the raw form as firewood. It is a renewable source of energy that is readily available to the poorest households in Zimbabwe. The scope of its use in Zimbabwe is multi-faceted and is still being explored. The same is being done about its impact. This paper has laid the background work that will inform future work on biogas and its impacts in Zimbabwe.

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