African Journal of Economics and Sustainable Development
ISSN: 2689-5080
Volume 3, Issue 1, 2020 (pp. 24-32)
www.abjournals.org

VALUING BIOGAS PRODUCTION FROM SOCIO-ECONOMIC AND ENVIRONMENTAL DIMENSIONS

Chot Chuol Nyang[1], Pius Mbuya Nina[1,3], Aliyu Umar Husseini[2]

[1]Department of Environmental Science & Management, International University of East Africa, P.O Box35502 Kampala.
[2] Department of Natural Resources, Nkumba University, Kampala
[3]Faculty of Agriculture, Uganda Martyrs University, P.O Box 5498, Kampala

ABSTRACT: *In spite of biogas technology having been in use in Kampala for over thirty years, it is only recently that the popularity of biogas technology began to increase due to government and non-governmental agencies efforts aimed at promoting renewable energy. In this study, thirty-five households with installed biogas digesters were visited and, after obtaining the consent of household heads, interviews were carried out with plant owners. The interview question guide was designed to gather data on environmental, social and economic impacts of biogas use. We also sought additional information to understand current challenges relating to biogas technology adoption, which information was meant to generate insights into the future of biogas in the energy sector. The results revealed that 34.3% of households with biogas digester still use other sources of energy for cooking besides biogas. Among the benefits of using biogas instead of unclean energy sources like charcoal and firewood, less emissions were ranked highest for environment (71.4), household savings as important economic benefit (74.3%) and convenience of cooking using biogas as a leading social benefit (77.1%). In contrast, large initial capital (82.9%) stood out as the biggest challenge to biogas adoption in Kampala. In conclusion, it was unlikely for the very poor in informal settlements to invest in biogas due to a lack of financial savings required for the installation. Energy sector should create a platform which can allow credit access for biogas digester installation, payable on small daily savings for a period sufficient enough to facilitate repayments. Otherwise alternative methods of financing are necessary for slum dwellers in order for the majority of Kampala residents without livestock to gain access to biogas technology.*

KEYWORDS: Biogas Technology, Urban Poor, Constrains, Material Benefits

INTRODUCTION

The concept of biogas in Uganda started in 1985 when the then Vice President of Uganda visited China on a business trip and was shown how villagers in rural china reap from the usage of biogas energy. On his return to Uganda the Vice president came with three experts to train Ugandans in the production and usage of biomass energy. But because this was a period of political turmoil and liberation wars, the plan did not work, so the project did not take off. It is from such a background that the current utilization and production of biogas in Uganda is still low. In developing countries such as Uganda where food is scarce and reliable energy supplies are even scarcer, necessity often becomes the mother of invention. It is possible for farmers to use human urine and excreta mixed in with banana peels, algae, water hyacinth, cow dung and poultry droppings as an inexpensive source of biogas. In Uganda's Kampala district where the

technology is being used for cooking, lighting pressure lamps and in various suburbs the residents are already reaping the benefits: Many are pulling themselves out of poverty and are using its by-product, "slurry," to enrich their soil, contributing to larger crop outputs (Al Seadi T. et al., 2008).

By using biogas, many advantages may arise. In Uganda, utilization of biogas would generate enough electricity to meet up to three percent of the country's electricity expenditure. In addition, biogas use for household cooking could potentially help reduce global climate change. Normally, manure from animal waste that is left to decompose releases two main gases that cause global climate change: nitrous dioxide and methane. Nitrous dioxide warms the atmosphere 310 times more than carbon dioxide and methane 21 times more than carbon dioxide. By converting cow manure into methane biogas via anaerobic digestion, the hundreds of cows in Uganda would be able to produce many kilowatt hours of electricity, enough to power hundreds of homes across Uganda (Arnell et al., 2007).

As it stands today, Germany is the world's biggest biogas producer and the market leader in biogas technology. Biogas plants operating throughout the country was estimated at 5,905 in 2010; Lower Saxony, Bavaria and the eastern federal states are the main regions. Most of these plants are employed as power plants. Usually the biogas plants are directly connected with electric power by burning the bio methane. The electrical power is then fed into the public power grid. Biogas in Germany is primarily extracted by the co-fermentation of energy crops mixed with manure. The main crop used is corn. Organic waste and industrial and agricultural residues such as waste from the food industry are also used for biogas generation. The level of development varies greatly in developed countries. While countries such as Germany, Austria and Sweden are fairly advanced in their use of biogas, there is a vast potential for this renewable energy source in the rest of the continent, especially in Eastern Europe. Different legal frameworks, education schemes and the availability of technology are among the prime reasons behind this untapped potential. Another challenge for the further progression of biogas has been negative public perception (Bekker, 2007)

Biogas production in most developing countries particularly Uganda has not been exploited. The main biogas deposit in Uganda as at 2015 was found in Mubende district and the Mobuku Irrigation scheme. But these facilities have since been run down by poor government policies of reconditioning and maintaining them for mass production. Biogas is an inflammable gas produced by bacteria in the process of fermentation of organic matter such as animal manure under anaerobic conditions. Biogas fuel is an important contribution and improvement of natural resources and environment through provision of energy for cooking and lighting at cheaper costs. It can be used as a tool for clearing and digesting animal manure making it better and ready as fertilizer for use in gardens and fish ponds as it helps improve the sanitary conditions in homesteads.

There is a research gap in the available literature about the environmental impacts of the utilization of biogas fuel over other fuels in Uganda. This is because biogas production in Uganda is still low and undeveloped mainly because of technological problems like the lack of enough advanced skills and techniques for producing biogas on a mass scale. Another problem that creates a literature gap is the fact that biogas is not affordable to the common man in Uganda, which has made the use of other fuels like firewood, kerosene and charcoal rampant. Dangers associated with the production and usage of biogas as energy is another deterrent factor because it cannot be measured or controlled given the weak technologies in place. Like

many sub-tropical regions, Uganda depends primarily on wood for energy. Rural households cook their meals on firewood and charcoal. Urban dwellers predominantly utilize charcoal for cooking. Due to inefficient use of wood fuels and increasing population levels, widespread reliance on such fuel is resulting in deforestation throughout Sub-Saharan Africa. Moreover, the burning of wood fuel contributes to greenhouse gas emissions and pollution. In Kampala, use of biogas would potentially help reduce greenhouse gas emissions and associated global climate change. Therefore, biogas production in Kampala and Uganda at large is an aspect still lacking and needs to be tapped. The major sources of energy for domestic uses are firewood, charcoal, kerosene and limited electricity and solar among others. Most of these fuels are expensive and some environmentally intolerable.

The advantage of using biogas fuel over other fuels in developing countries like Uganda, is that biogas is being smokeless, reduce amount of petroleum products needed by a household, saves household time and money as well as firewood. The gas is nonpoisonous and can be readily available from everyday raw materials from farm by products like waste from cattle, pigs and chicken. Organic waste and water are essential sources of biogas and can be collected in one place. This study is therefore aimed at assessing the economic and social impact of using biogas over other fuels in developing countries utilizing a case study of Kampala (Eawag, 2008).

MATERIALS AND METHODS

Research Design

The research takes the form of a case study, and the reason for this is because biogas usage and its benefits are a wide study scope and utilizing a case study would offer enough relevant data that can be used to depict the entire country. The study is both qualitative and quantitative. The quantitative data will be obtained using structured questionnaires from different categories of key informants, while the qualitative data will be obtained by interviews and observations. A qualitative approach will be considered because it enables draw conclusions in terms of concepts and analysis in terms of understanding, what, where, who among other queries, while the quantitative research approach will be opted for in cases where data needs to be tabulated or represented in graphs or pie charts for easier comprehension.

Sources of Data

The major sources of information were entirely primary and secondary which were sought by the researcher in order to address the study objectives. Data on the research variables under investigation will be obtained from the various sources depending on availability and ease of access.

Primary Data

Primary data were obtained from respondents who were selected to participate in the study and responses generated from structured and semi-structured questionnaires that were prepared by the researcher. The researcher conducted field research where interviews and questionnaires were administered to the selected respondents to obtain information from the respondents. Hence interviews and questionnaires constituted instruments for primary data collection.

Secondary Data

The whole process of collecting secondary data involved a critical examination of existing literature from textbooks on biogas usage, search engines for rural electrification agency journal articles, NAADS annual records, magazines and thesis reports to comprise the literature.

Data Quality Control (Reliability and Validity of Instruments)

Validity and reliability were secured by pre-testing the research instruments before setting out to the field to ascertain whether they actually provide answers to the research variables and questions. Secondly, the researcher double checked the instruments used both in the field and out of the field in order to do away with omissions and errors. Reliability was also achieved by using triangulation and a representative sample size for final findings drawing.

For purposes of analyses and determining the accuracy and consistence of the instruments, questionnaires were pre-tested with 10% of the respondents at the study area with the guidance of experts from the University, most especially the researcher's supervisor. Data that were collected from the key informants using the interview schedule and self-administered questionnaires acted as a quality check. Thereafter, the researcher proceeded to administer the instrument to respective respondents at household level in the study area.

Measurements and Sampling Procedures

The sampling procedure for this study was purposive sampling of those households whose occupants are currently using biogas. This sampling approach offered a great chance of selecting appropriate respondents with useful information for this study; people who are directly involved in biogas either as users, promoters, producers and agents who then formed the subgroup of key informants. It was used by identifying those people deemed to be having direct and detailed data about the issue under study. Those people were then involved through face to face contact. In this study the sample size comprised 35 respondents who included; (15) local farmers, (5) Electricity Regulation Authority officers (ERA), (5) NAADS officers, (5) academicians and (5) randomly selected members of the public.

Data Collection Tools

Data collection in this study involved use of various data collection methods to minimize invalidity and ensure reliability of findings.

Interview Methods

Personal interviewing was used because it enables a researcher to get satisfactory results, during the interview process for achieving the specific objectives of the study, considering the different types of fuels used in the study area.

Questionnaire Administration

This method involves the researcher using pre-set list of questions to draw responses or opinions from the respondents for achieving all the study objectives.

Observation

Through observations, the researcher got first hand data on the economic and social impact of using biogas over other fuels in developing countries as it enables the researcher see the reality and judge for herself.

Focus Group Discussions

The researcher consulted different people who have relevant knowledge on the economic and social impact of using biogas over other fuels in developing countries through an open debate with the respondents.

Data Analysis

The data will be manually collected, processed and analyzed by the researcher using methods of analysis. Data will be analyzed using content analysis; where by answers from successive interviews will be crosschecked with those from the researcher observation to ensure authenticity geared towards ensuring accuracy legibility and comprehensiveness of the research outcomes. Major issues or topics will be classified to produce theme and sub-themes that will be reviews to underline key questions, insights, explorations and interpretations. This will be aimed at organizing data into meaningful categories so that it is easy to interpret and understand.

RESULTS

Socio-Demographic Characteristics of Food Handlers

Table 1: shows the sex and age of the respondents that were selected for the assessment of biogas use and its social and economic benefits to the communities in Kampala, Uganda. Majority of respondents were aged bellow 35 years while men formed the highest percentage (57.2%) of the respondents during the study.

Table 1: Age and Sex of Respondents

		Percentage (%)	
Age	Frequency	Females	Males
18-25 years	04	08.6	02.9
26-35 years	22	22.9	40.0
36 + years	09	11.3	14.3
Total	35	42.8	57.2

The majority of respondents (60%) had obtained tertiary level of education, while only 31.4% were high school leavers. Therefore, up to 91.4% respondents were people who could easily read, understand and provide the right responses to the questions. This means that an insignificant number (8.6%) respondents needed guidance of the research during the questionnaire interviews. In general, regardless of the education level, there were more male respondents working in farm related activities as well as biogas projects compared to their female counterparts.

African Journal of Economics and Sustainable Development
ISSN: 2689-5080
Volume 3, Issue 1, 2020 (pp. 24-32)
www.abjournals.org

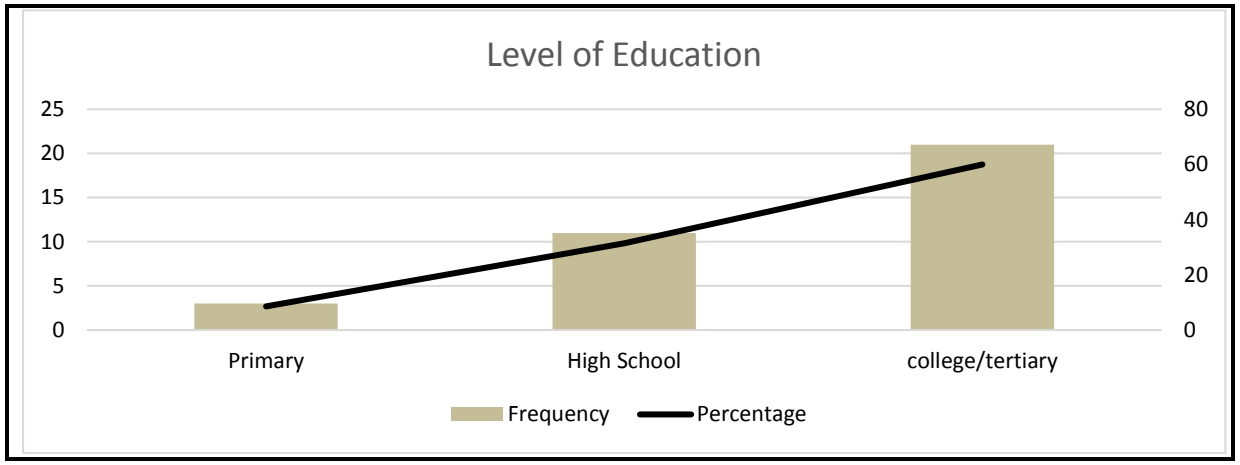

Figure 1: Education Background of Respondents

Various Types of Fuels Kampala Residents Use

The study documented and ranked different types of energy sources which communities residing in Kampala rely on for cooking and lighting their homes. The results presented in Table 2 show that biomass fuels are the most popular and widely used. For instance, the respondents' households fully (100%) rely on biomass energy sources for cooking. Majority of the local communities were unable to afford purchasing modern energy sources like hydro-power and gas. These findings are consistent with the results obtained for other countries in least developed countries.

Table 2: Energy sources of fuel for cooking

Focus	Main Energy source	Frequency	Percentage
Individual level	Biogas	23	65.71
	Firewood	2	5.71
	Charcoal	10	28.57
	Electricity	0	0
	Kerosine	0	0
Total		**35**	**100**
Community level	Biogas	2	5.71
	Firewood	7	20
	Charcoal	22	62.86
	Electricity	3	8.57
	Kerosine	1	2.86
Total		**35**	**100**

Benefits of Biogas Use as Perceived by Respondents

The respondents reported several benefits which they derive from using biogas as alternative and, or sole source of energy for household cooking. Less emissions and improved air quality were the most rated environmental benefit, while savings as people in households where biogas is used as sole source of energy no longer buy charcoal tops in the list of economic benefits. Finally, ease and convenience during cooking was considered the most among social benefits of biogas use.

Table 3: Types of Benefits Associated with Biogas Use

Issue	Perceived Value	Frequency	%
Environmental	Less emissions improves air quality	25	71.43
	Waste reduction from the surroundings	22	62.86
	Lowers risk of indoor pollution	07	20.00
	Slows down deforestation and degradation	21	60.00
Economical	Reduces energy cost once installed	22	62.86
	Efficient cooking and time saving	14	40.00
	Savings as people stop buying charcoal	26	74.29
	Invest savings in other household items	18	51.43
Social	Clean cooking surroundings; clean hands	19	54.29
	New jobs created in materials supply	17	48.57
	Prestigious to use, raise one's status	23	65.71
	Convenient, no adding of fuel during cooking	27	77.14

Challenges in Promoting Biogas as Clean Energy Source in Kampala

Poverty associated with households' low-income levels was a major hindrance to biogas use adoption in Kampala sub-urban areas of Kawempe and Makindye divisions where this study was conducted. The respondents highlighted various challenges which were analyzed and presented in different categories as shown in Table 4 below.

Table 4: Major Challenges Facing Adoption of Biogas use in Kampala

Issue	Reported Concern	Frequency	Percentage
Economic	Large initial capital is prohibitive	29	82.86
	Materials not available, or in low supply	18	51.43
	Expensive to most poor households	21	60.00
Technical	Lack of knowledge on biogas	12	34.29
	Installation difficulties	16	45.71
	Lack of maintenance skills	22	62.86
Social	Low public sensitization on clean energy	14	40.00
	Labour intensive for household members	09	25.71
	Risk to the users/delicate to handle	31	88.57

The costs of biogas system operating and maintenance include the cost of manpower required to dig pit, construct digester and operate the system, as well as the cost of inputs (Purohit and Kandpal, 2007). Acquisition of raw materials for the substrate and water for mixing materials is problematic in most sub urban areas of Makindye division in Kampala. On technicalities, the respondents cited feeding and operations of the plant, including regular maintenance, supervision, storage and disposal of the slurry, gas distribution and utilization, as well as administration at household level as some of the challenges associated with installation and running a biogas plant (CAEEDAC, 1999).

CONCLUSIONS

The study concluded that biogas use is currently being appreciated by members of households which have adopted its use as clean and cheap source of energy. However, this was a very small fraction of the urban population, which means that majority urban dwellers still rely on unclean sources of energy like firewood and charcoal to cook their meals. In order to avoid energy crisis in the near future, as charcoal supply drops significantly and charcoal prises continue to rise, biogas offers a way out of this quagmire. The government of Uganda together with international agencies working with marginalised poor urban communities should rethink new approached to promoting biogas installation and use in peri-urban areas of Kampala.This study did not quantify gas production. Therefore, further research needs to quantify biogas produced per unit of raw material (organic) used on a monthly basis. Similarly, the value of by-products (contents of the digester) after biogas production should be assessed in terms of suitability for use as fertilizer or final disposal into the environment.

Acknowledgements

The authors are grateful to the respondents who participated in this study and particularly to the individual households that generously gave the information. We also thank local leaders (LC1s) for their support during the introduction and planning for data collection.

REFERENCES

Al Seadi T. et al. (2008). Biogas Handbook. Biogas for Eastern Europe. University of SouthernDenmark. ISBN 978-87-992962-0-0

Arnell M. et al. (2007). Operational experience of cost-effective production of biogas in Linköping, Sweden, Integrated Porject N° 019795, Biogasmax.

Bekker M. (2007). Charakterisierung der Abbaubarkeit von spezifischen organischen Stoffen.Hahn, H.H. (Ed), Karlsruhe.

Biolley L. and Diggelmann R. (2011). Biogas from Solid Waste - Development and Further Engineering of Dry Fermentation Technology in Kumasi, Ghana. BSc Thesis. University of Applied Sciences (ZHAW) and Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland.

Deublein D. and Steinhauser A. (2011). Biogas from waste and renewable resources: an introduction, Wiley -VCH Verlag GmbH & Co. KGaA.

Eawag (2008). Global Waste Challenge. Situation in Developing Countries. Swiss FederalInstitute of Aquatic Science and Technology. Dübendorf, Switzerland.

Eder B. and Schulz H. (2007). Biogas Praxis - Grundlagen, Planung, Anlagenbau, BeispieleWirtschaftlichkeit. Ökobuch Magnum. Staufen.
Gupta, Sujata (6 November 2010). "Bio gas comes in from the cold". New Scientist (London: Sunita Harrington). p. 14.
House D. (2010). The Complete Biogas Handbook. Alternative House Information, 288 pp.
Igoni A. H., Ayotamuno M. J., Eze C. L., Ogaji S. O. T., Probert S. D. (2007). Designs of anaerobic digesters for producing biogas from municipal solid waste. Applied Energy 85, p.430 – 438.
Persson M., Jönsson O., Wellinger A. (2006): Biogas upgrading to vehicle fuel standards and grid injection. IEA Bioenergy.
Richards, B.; Cummings, R.; White, T.; Jewell, W. (1991). "Methods for kinetic analysis of methane fermentation in high solids biomass digesters". Biomass and Bioenergy 1 (2): 65–26.
Richards, B.; Herndon, F. G.; Jewell, W. J.; Cummings, R. J.; White, T. E. (1994). "In situ methane enrichment in methanogenic energy crop digesters". Biomass and Bioenergy 6 (4): 275–
Schnürer A. and Jarvis A. (2010). Microbiological Handbook for Biogas Plants. Swedish Waste Management U2009:03 Swedish Gas Centre Report 207.
Tower, P.; Wetzel, J.; Lombard, X. (March 2006). "New Landfill Gas Treatment Technology Dramatically Lowers Energy Production Costs". Applied Filter Technology.
UNFCCC (2010). The Kyoto Protocol Mechanism - International Emission Trading, Clean Development Mechanism, Joint Implementation. United Framework Convention on Climate Change.
Wieland, P. 2012/pdf "Biomass Digestion in Agriculture: A Successful Pathway for the Energy Production and Waste Treatment in Germany". Engineering in Life Science.
Zurbrügg C. (2003). Solid Waste Management in Development Countries. Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland.