Impacts Of Biogas Production On Improvement Of Rural Access To Energy In Sierra Leone

1. Introduction

Electricity is a basic human need and a critical element on which the socio-economic development of a nation depends. In Sierra Leone and some other developing countries, access to clean and affordable energy in rural areas is so low that it is considered a privilege, but is actually the 7th Sustainable Development Goal, a component of the 2030 agenda for sustainable development adopted in 2015 (UNDP, 2019). As a Sierra Leonean interacting with rural dwellers, I have realized that access to reliable electricity is a prime mover for rural development as it contribute to increasing agricultural productivity, and access to clean energy for cooking leads to improved living standards. This has motivated me to conduct this research at BIGS-DR, under the ZEF theme Land, water, food and energy.

Sierra Leone has a population of about seven million (7,000,000), of which Fifty-nine percent (59%) lives in rural areas (Statistics Sierra Leone, 2016), which are the most underdeveloped areas in the country. Rural dwellers are underprivileged and lack access to basic social amenities. I am passionate about using my education and technical know-how to help these people get the opportunities they need to improve their living standards, through biogas development, because human development focuses on people, their opportunities and choices (European Commission, n.d.). Biogas is a mixture of predominantly methane and carbon dioxide, obtainable from the anaerobic digestion of biodegradable waste; a clean fuel for cooking and electricity generation (Lambert, 2017) and the waste from the process is a high-value bio-fertilizer that can be applied directly to farmlands (Achinas, et al., 2017). This research topic is timely because despite the challenges in the energy sector, there has not been significant effort in the country to promote research and development on waste management and waste-to-energy conversion.

2. Problem Statement and Justification of the Study

There have been improvements in the electricity transmission and distribution network mainly in the capital city, Freetown, thanks to support from the World Bank and other international institutions, yet, only about 20% of Sierra Leone’s population have access to grid electricity. Based on my experience in the energy sector, distribution of electricity to rural areas through centralized grid connection is complex as demands are scattered and involves high technical losses. Thus, biogas production is a decentralized and sustainable means of means of improving rural access to electricity and clean energy for cooking.

Energy poverty severely affects educational productivity, and it is an obstacle to indigenous and foreign investment that eventually contribute to reduction of access to employment and decent work in the world’s most underdeveloped countries. By 2017 for instance, only about 5.4% of Sierra Leone’s rural population had access to electricity (The World Bank Group , 2017), and the 2019 Energy Progress Report revealed that less than 10% of Sierra Leone’s population have access to clean cooking fuels and technologies (IEA, IRENA, UNSD, WB, WHO , 2019).

This has led to heavy reliance on firewood and charcoal for cooking, which is contributing to deforestation, leading to soil erosion, loss of arable land, and eventually threatens food security.

About 80% of the energy supply in Sierra Leone comes from biomass, but consumed through inefficient burning of mainly firewood and charcoal for cooking, followed by imported petroleum products, which make up about 13%, used mainly for transportation and private electricity generation, while the remainder is accounted for by grid connected electricity generation from fossil-fuel power plants. The energy potential of biomass in Sierra Leone has been estimated to be 2.706GWh from waste resources, but have remained untapped, as there has not been any major biogas production facility despite rural access to energy remains shockingly low. A major challenge in addressing energy poverty is the lack of awareness and commitment in enacting appropriate energy and environmental policies, and promoting research and development (Kemausuor, et al., 2018). Nonetheless, Africa including Sierra Leone is still considered “the most powerful future biogas market” (Yousuf, et al., 2016).

To this end, I need this opportunity to extensively research under the supervision of energy and development experts at BIGS-DR to promote biogas development in Sierra Leone to replicate the success stories in some African countries. In Kenya for instance, a 2.2MW commercial biogas plant commissioned in 2017 is reported to be the largest grid-connected biogas power plant in Africa, injecting 2MW of electricity into the grid to meet the needs of about 6,000 rural homes (Kamadi, 2017). Compared with solar and wind power that are weather dependent, a particular advantage of biogas is that it can be stored and available on demand (Lebuhn, et al., 2014), with other key benefits including job creation, reduced fossil fuel imports and reduction in deforestation (Jiang, et al., 2011).

3. Research Questions

To contribute to knowledge on the extent to which biogas production could improve rural access to energy, I intend to answer the following research questions:

1. How much biogas can be produced, and to what extent it can improve rural access to energy?
2. What are the barriers to successful biogas deployment and how can they be overcome?
3. What are the potential benefits to the environment, contribution to agricultural productivity, and socio-economic benefits to rural dwellers?

4. Research Objectives

This study aims at investigating and determining the biogas production potential in Sierra Leone for the successful deployment of small to large-scale anaerobic digesters to improve rural access to energy. To achieve this, the research will focus on the following set of objectives:

1. Analyse the existing energy production statistics, and the impacts on the economy and the environment, and the livelihood of people.
2. Estimation of waste availability and determination of the suitability for conversion into biogas.
3. Develop a model to estimate biogas production from various waste resources.
4. Develop a business case to analyse the costs and benefits of commercial biogas

production.
5. Estimate the potential contributions of biogas production on Gross Domestic Product (GDP) and critically assess the environmental impacts.

5. Research Methodology

This study will commence with extensive reading/review of the energy situation in Sierra Leone to identify specific study areas. The scope of the research will be limited to rural areas of Sierra Leone, and will focus on collecting and analysing data to estimate the biogas potential and its impact on the people of Sierra Leone. Qualitative research method will be used to review and evaluate the state of energy supply in rural areas, energy and environmental policies, and their effects on people's livelihoods, while Quantitative method will be used to answer the research questions how much?, and to what extent?.

5.1 Data Collection

Energy production and utilisation data in the power and non-power sectors will be collected through a desk study by studying documents and records from relevant local institutions, and from the websites of relevant international institutions during the first year. In the second year, questionnaires will be used to collect primary data from local institutions by interviewing policy makers in the energy and environment sectors, and a different questionnaire will be used to collect data from rural dwellers in the study areas to sought information on how lack of energy access is affecting their livelihoods. Data on waste generation will be collected using a household door-to-door survey approach for a specified number of randomly selected households in selected urban and rural communities. While the focus is on rural areas, urban areas are considered for the possibility of using their waste resources for the benefits of the rural dwellers. This approach will involve waste collection between one to seven days, and waste sorting and weighing to determine their composition and rate of waste generation per household. During this process, potential sites for the installation of anaerobic digesters will be identified in various rural communities.

5.2 Data Analysis

Statistical Package for the Social Sciences (SPSS) software and other analysis tool that might be deemed necessary will be used to perform statistical analysis on data collected. SPSS will be used to perform regression analysis with existing secondary data to examine how the share of fossil fuels, renewables and other energy sources, policies and regulations have impacted the lives of people. Waste composition will be analysed using The Ultimate Analysis (i.e. the process of determining the elements in a compound, which in this case is the waste). With knowledge of the chemical composition of waste, biogas yield will be estimated using Boyle's formula, and/or a more suitable method that may be realised during the course of the study, and the biogas yield will be used to estimate the energy potential (i.e. the kilowatt-hour (kWh)) per unit of biogas produced. A business model will be developed using Microsoft Excel to do a cost-benefit analysis of biogas production from the resulting waste availability to determine the cost of producing biogas, the expected revenue, and the Levelised Cost of Energy (LCoE). The LCoE will be compared with energy recovery from other sources to ascertain the economic viability of biogas deployment.

5.3 Research Timeline

The research will commence on 1 October 2020 and completed by 30 September 2023, during which it is proposed that three papers will be published. Their proposed titles are as follows: Paper 1: Impacts of energy and environmental policies on the state of energy access in rural communities, Paper 2: Biogas potentials and its contribution to the energy mix of Sierra Leone, and Paper 3: Economic and environmental impacts of biogas production in rural communities. The Gantt chart in page 5 below shows the proposed research timeline.

6. Potential challenges and expected results

The main challenge will be the time required to obtain data from the local institutions and there will be challenges in administering questionnaires in the rural areas because of the level of education of the intended respondents. Nonetheless, I will utilise my indigenous knowledge and persuasive skills to convince targeted respondent to co-operate by helping them understand the potential benefits of this study to the country. For rural dwellers, I intend to secure the services of highly motivated interns from local universities to serve as interpreters where necessary. Despite the challenges, it is expected that this study will provide results that will suggest that there is a reasonable potential for biogas production to improve access to energy in rural communities, amid effective policies, regulations and support from government.

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